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ABSTRACT

This supplementary report identifies and provides individual descriptions and reviews of 71 retirement forecasting models. Composed of appendices, it is intended as a source of more detailed information than that included in the main volume of the report. Appendix I is an introduction. Appendix II contains individual descriptions of 32 models of federal retirement program costs; appendix III, 35 models of civilian retirement decision behavior; and appendix IV, 4 models of retirement income. Each appendix includes a summary of contents and a table that cross-references the contents to the main volume of this report, which summarizes the individual reviews. References to literature sources for each model are provided immediately after each description. Individual descriptions for models of all three retirement outcomes researched (program costs, civilian workers' retirement behavior, and levels and distribution of retirement income) include: (1) model identification (name, sponsor and/or developer and address); (2) background and use (primary objective of model; prior, current, and/or planned use); (3) model description (outcomes predicted, methods of calculation and/or simulation, data sources, predictors of outcomes and/or specific predictor values/assumptions); and (4) model review (availability of documentation, frequency of updating or model maintenance, available information on model validity). A 22-page bibliography lists the references cited in the descriptions and others consulted in preparing the report. (YLB)

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United States General Accounting Office

GAO

Report to the Chairman, Subcommittee on Social Security and Income Maintenance Programs, Committee on Finance United States Senate

December 1986

RETIREMENT FORECASTING

Technical Descriptions of Cost, Decision and Income Models

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GAO/PEMD-87-6B Volume 2

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United States
General Accounting Office
Washington, D.C. 20548

Program Evaluation and
Methodology Division
B-221754

December 31, 1986

The Honorable William L. Armstrong
Chairman, Subcommittee on Social Security
and Income Maintenance Programs
Committee on Finance
United States Senate

Dear Mr. Chairman:

In our basic continuing legislative responsibility to evaluate government programs, we initiated a review of retirement forecasting models. This is the second of two volumes of our report. The report presents information we gathered on 71 models that collectively forecast three retirement outcomes: (1) the costs of federal retirement programs, (2) the retirement behavior of civilian workers, and (3) the levels and distribution of retirement income.

This supplementary report identifies and provides individual descriptions and reviews of 71 retirement forecasting models: 32 models of federal retirement program costs, 35 models of retirement decision behavior, and 4 models of retirement income. The main volume of the report provides an overview of retirement forecasting; an explanation of our objectives, scope, and methodology; a summary description of each of the three categories of models; and conclusions and matters for consideration by the Congress with regard to the federal interest in retirement forecasting models. The supplementary volume is intended as a source of more detailed information for readers interested in reviewing specific characteristics of the models.

This volume will be distributed to those who received the first volume, and it will be made available to others who request it.

Sincerely,

Eleanor Chelimsky
Director

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Abbreviations

AARP	American Association of Retired Persons
AFDC	Aid to Families With Dependent Children
ASPE	Assistant Secretary for Planning and Evaluation of the U.S. Department of Health and Human Services
BLS	Bureau of Labor Statistics
CBO	Congressional Budget Office
COLA	Cost of living adjustment
CPI	Consumer price index
CPS	Current Population Survey
CSRS	Civil service retirement system
DECO	Demographic-economic model
DI	Disability insurance
DOL	U.S. Department of Labor
DRI	Data Resources, Inc.
DYNASIM	Dynamic simulation of income model
EEOC	Equal Employment Opportunity Commission
FEH	Family and earnings history model
HHS	U.S. Department of Health and Human Services
IRA	Individual retirement account
IRS	Internal Revenue Service
JBH	Jobs and benefits history model
MDM	Macroeconomic-demographic model
MUPS	Mandatory universal pension system
NLS	National Longitudinal Surveys of Labor Market Experience
OASDI	Old Age Survivors and Disability Insurance
OASI	Old Age and Survivors Insurance
OPM	Office of Personnel Management
ORSIP	Office of Research, Statistics, and International Policy, Social Security Administration
PHS	Public Health Service
PRISM	Pension and retirement income simulation model
PSID	Panel Study of Income Dynamics
PVL	Pension valuation language
RHS	Retirement History Survey
SSA	Social Security Administration
STRS	State Teachers Retirement System
TVA	Tennessee Valley Authority

Appendix I

Introduction

This supplementary report volume identifies and provides individual descriptions and reviews of 71 retirement forecasting models: 32 models of federal retirement program costs, 35 models of retirement decision behavior, and 4 models of retirement income. The main volume of the report provides an overview of retirement forecasting, an explanation of our objectives, scope and methodology, a summary description of each of the 3 categories of models, and conclusions and matters for consideration with regard to the federal interest in retirement forecasting models. The supplementary volume is intended as a source of more detailed information for readers interested in reviewing specific characteristics of one or more of the models.

Report Organization and Contents

Appendix II contains individual descriptions of 32 models of federal retirement program costs; appendix III, 35 models of civilian retirement decision behavior; appendix IV, 4 models of retirement income. Each appendix includes a summary of contents and a table which cross-references the contents to the main volume of this report which summarizes the individual reviews. References to literature sources for each model are provided immediately after each description. These references, and others consulted in preparing both volumes of the report, are all listed in the bibliography at the back of this volume.

Individual model descriptions for models of all three outcomes include the following information:

Model Identification

- model name
- model sponsor and/or developer
- address of sponsor/developer

Background and Use

- primary objective of the model
- prior, current and/or planned use of the model

Model Description

- outcomes predicted by the model
- methods of calculation and/or simulation
- data sources
- predictors of outcomes and/or specific predictor values/assumptions

Model Review

- availability of documentation
- frequency of updating or model maintenance
- available information on model validity

References

Information Sources

Most information in this report came from publicly available documentation. Additional information was obtained from reviews of individual models (identified through a literature review) as well as from interviews with model developers, users, and experts in the field.

The sources varied across categories. Documentation for the models of retirement program costs was obtained primarily from reports submitted annually to GAO from federally administered retirement programs. Additional documentation for the Department of Defense model of the Military Retirement System, the Office of Personnel Management model of the Civil Service Retirement System and the Social Security Administration model of the OASDI program came directly from the agency developers.

Documentation for models of the retirement decision consists largely of the article or paper in which the model is described. We acquired these documents through libraries or direct requests to authors.

Documentation for retirement income models was obtained directly from the model developers. Although there are a limited number of models in this category, the documentation for these complex models is fairly extensive.

Strengths and Limitations

A key strength of this report is accuracy of description. In addition to our own checks, we provided model developers with drafts of the descriptions of their models prepared for this volume and invited their review for accuracy. Ninety-nine percent (70 of 71) of the developers responded and all identified errors were corrected. This does not imply that everything in the models is accurate.

With regard to limitations, our data collection was completed in December 1984, and it is likely that some new models have been developed in one or more of the categories, or at least that changes have occurred in existing models since that time. Second, for the one model whose developer did not respond to our request for review, completeness and accuracy are limited to the extent that the published documentation is limited. Third, our analyses are not as complete as in-depth model evaluations and therefore exclude some matters such as the verification of coding accuracy, test data validation, and the like.

Models of Federal Retirement Program Costs

In this appendix we describe 32 models which forecast the expected cost and financial status of retirement programs that cover federal employees. Public Law 95-595, the 1978 Amendment to the Budget and Accounting Procedures Act of 1950, requires all sponsors of federal retirement programs not covered under ERISA to report annually on their financial status. Among these programs are the Civil Service Retirement System (CSRS) and the Military Retirement System as well as 34 additional programs whose sponsors annually make forecasts to report on their financial status. In addition to models of these programs, we include the cost estimate models for the OASI program which also covers federal employees. (Although there is more than one model for the OASI projections, the collection of models is counted as only one.)

Although there are a total of 46 retirement plans covered by P.L. 95-595, we identified only 31 models (listed in table II.1). These models cover 36 plans: three models forecast outcomes for two plans each and one, for three plans. No models were identified for the remaining ten plans: six of these are defined contribution plans, one has no active employees, no reports have been filed for two plans and the last report filed for one plan was in 1980.

Table II.1: Identification of Program Cost Models

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GORGO—long-run valuation model of the military retirement system	2	28
Valuation model for the Foreign Service retirement and disability system	8	31
Valuation model for the judicial retirement system and judicial survivors' annuities system	21	32
Valuation model for the United States Tax Court retirement plan and survivors' annuity plan	31	33
Valuation model for the Public Health Service commissioned corps retirement system	10	34
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Valuation model for the retirement plan for civilian employees of United States Marine Corps exchanges, recreation funds, clubs, messes, and the Marine Corps exchange service	12	40
Valuation model for the U.S. Air Force nonappropriated fund retirement plan for civilian employees	11	41
Valuation model for the retirement annuity plan for employees of Army and Air Force exchange services	5	42
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Valuation model for the Farm Credit district of Baltimore retirement plan	22	47
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Valuation Model for the twelfth district Farm Credit retirement plan	20	50
Valuation model for the retirement plan for the employees of the seventh Farm Credit district	14	51
Valuation model for the retirement plan for the employees of the associations and banks of the ninth Farm Credit district	18	52
Valuation model for the Farm Credit retirement plan—fifth Farm Credit district	25	53

Model	ID number[a]	Page
Valuation model for the production credit associations retirement plan—fifth Farm Credit district	26	54
Valuation model for the Sacramento Farm Credit employees' retirement plan	19	55
Valuation model for the sixth Farm Credit district retirement plan	17	56
Valuation model for the group retirement plan for federal land bank associations, production credit associations, and Farm Credit banks in the first Farm Credit district	24	57
Valuation model for the Farm Credit institutions in the fourth district 1979 amended retirement plan	13	58
Valuation model for the Farm Credit retirement plan—Columbia district	16	59

[a]Model identification numbers correspond with ones used in table 2.1 in chapter 2 of the main volume of this report.

Model descriptions are based on the structure presented in appendix I, with more detail provided for models of the three largest programs, OASI, CSRS and Military Retirement, than for the 29 models of smaller programs. Each description was reviewed for accuracy by the model developer and all identified errors were corrected. A summary of the individual model descriptions is provided in the main volume of this report. There we refer to individual models by identification numbers. These numbers are provided in table II.1 for cross-referencing.

OASDI Cost Estimate Models

Further information about these models is available from their developer: Office of the Actuary, Social Security Administration, Baltimore, MD 21235.

Background and Use

There are two major models developed by the Office of the Actuary at the Social Security Administration which are used to estimate costs of the OASI program — the short-range and long-range OASDI cost estimate models. (The OASDI models estimate costs for both the OASI and DI programs. The focus of our report is the OASI program.) These models are used primarily to generate projections for the Annual Report of the Trustees. Outputs from these and a variety of auxiliary models which we have called the "revised version" were used by the National Commission on Social Security Reform in its 1983 report to assess the financial impacts of proposed changes in the social security system.

The goal of both the short-range and long-range OASDI cost estimate models is to project future expenses and future revenues and compare the two estimates by calculating future cost ratios and future balances.

In both models, expenses are estimated fairly independently of revenues. The short-range model makes annual projections out to ten years. The long-range model makes forecasts which extend out 75 years. Although both models produce estimates for the initial ten years in the projection period, those from the short-range model are used in calculations of both the short-term and the long-term financial status of the program. Projections for the initial ten-years from the long range model are monitored for consistency with the comparable forecasts from the short-term model to insure a smooth transition when projections are combined.

Although the Office of the Actuary has been producing cost estimates for about 50 years, it is inappropriate to view these estimates as coming from models with a 50-year history. Over the years, the procedures used to derive the final estimates have changed substantially. The models described in this report are those used to generate the estimates for the 1983 Trustees Report. These models reflect the major methodological revisions done in 1981. The models are updated and revised annually. Although no major revisions were under consideration as of 1984, it is likely that such revisions will be made as new procedures or better quality data become available.

The OASDI cost estimate models are the most widely used of the models described in this report. These forecasts are central to monitoring the financial status of the social security program and assessing the need for program changes. In addition, quarterly estimates from the short-range model are used internally by the Social Security Administration for routine budgetary planning for the program.

The models' forecasts are also used widely by other model developers to constrain or assess the validity of output from their own models concerning future costs of the OASI program. And, the economic and demographic assumptions of the model, which are revised annually, are used as assumptions in a variety of models forecasting variables other than retirement program costs.

Model Description

Both of the OASDI cost estimate models have three major estimation components. These components forecast the number of future beneficiaries in a given year, the average benefits payable to those beneficiaries and the future annual payroll for workers in social security covered employment.

In both models, each major estimation component is performed fairly independently of the others, although the outputs of each component are monitored for consistency. The primary source of dependence across components is a common set of explicit economic and demographic assumptions. These assumptions are derived from a combination of empirical data, other model forecasts and expert judgment.

The outputs from these three components are combined mathematically to produce the final outputs or forecasts from the model. Total future benefit payments, which are the primary source of future expenses, are determined by multiplying estimates of the number of future beneficiaries in various categories by estimates of the average benefits payable to beneficiaries in those categories. Future taxes, the primary source of future revenues, are estimated by applying appropriate tax rates to estimates of future covered payroll. Final estimates of future expenses and revenues are then compared to determine the financial status or balance of the program's trust funds. An additional standard output from both models is a future cost ratio—expenses expressed as a percentage of taxable payroll.

Although both the short- and long-range models have components with similar forecasting goals, the procedures used within each component are somewhat different for the two models. These components are summarized separately below.

Procedures Used to Estimate the Number of Future Beneficiaries

For the OASDI cost estimate models, retirement is defined as receipt of social security benefits by covered workers. The output from the model component which estimates future retirees is the projected number of beneficiaries in each of several categories for each year in the upcoming ten-year period and every five years thereafter to a 75-year limit.

These estimates are derived for the short-run by estimating sequentially for each year in the projection period the social security area population, the proportion of that population which is fully insured, and the proportion of the fully insured population aged 62 and over who will apply and qualify for benefits. Estimates of the size of the last group are then used to project the number of people who will actually receive benefit payments in a given year.

The current area population estimate is made by supplementing the current U.S. Census population estimate with an estimate by Census of the population undercount, an estimate based on Medicare program data of

the population age breakdown for individuals aged 65 and over, and estimates based on data supplied by the Bureau of the Census, the State Department, and the Maritime Administration of the populations in outlying regions which are covered by social security but not included in the U.S. Census. These initial individuals are further broken down by age of husband and age of wife by prorating figures available from the 1970 Census. The resulting estimate of the current area population is projected into the future by applying dynamic assumptions of future fertility, mortality, net immigration, marriage and divorce rates.

Estimates of the number of future beneficiaries are derived by sequentially applying a series of trend extrapolations to this estimate of the current social security area population. Past trends in population insured rates, rates of application for benefits, award rates, termination rates and rates of entry of applicants into payment status are extrapolated into the future using a variety of methods. Some rates, like award rates, are determined by visually/judgmentally estimating the past trend's future asymptote and then interpolating between the present and the asymptotic values to yield annual rates for intervening years. Other rates, such as the rate of entry of applicants into payment status are estimated by extrapolating from linear regression equations developed on time series data. The quantitative sophistication of the trend extrapolation procedure used is determined in part by the sensitivity of the forecasts to rate differences and in part by the perceived variability or estimability of the rate. Each of these rate projections is then applied to the future population estimates to yield estimates of the number of future beneficiaries, the final output of the model.

For the long-term forecasts, the fully-insured population is projected based on past and projected covered-worker rates for each cohort. The number of beneficiaries is then projected through multiplication of beneficiary prevalence rates and estimates of the fully insured population. In previous years, prevalence rates were based solely on past trends. For the 1983 forecast, prevalence rates were adjusted to account for changes that might occur in the future when the normal age of retirement is raised, starting in 2002.

Procedures Used to Estimate Average Benefits Payable to Future Beneficiaries

The method used at the time of our review to estimate average benefits payable was introduced in 1981. Developers indicated that future revisions in the method could be made if better quality data became available.[1]

The estimation model simulates work histories and salaries for a sample of prospective beneficiaries and applies expected benefit rates, COLAs and changes in the earnings base to yield a data base which contains annual estimates of future benefits for the simulated sample.

The base sample used to conduct the simulation was created by pooling individual observations from two data bases and adding theoretical cases not otherwise represented. The largest part of the sample comes from the Continuous Work History Sample file, an administrative data base maintained by the Social Security Administration. Workers who have accepted benefits were sampled from this file, which contains the annual earnings base for each individual. For FY85 model estimates, the data was current through 1978. The data will be updated for FY86 estimates to include 1979 earnings. The second component of the base sample consists of a sample of others who had earnings but were not insured by the OASI program. This group, largely women, was selected from the 1973 Current Population Survey (CPS-IRS-SSA Exact Match File). In addition to these two sets of observations, the base sample includes theoretical cases, again largely women, of individuals with no earnings history.

The model assumes that future work histories will be comparable to those observed in the past and thus historical information on the base sample is used to project future work patterns. Future salaries are adjusted to reflect expectations about future wage rates. Aggregate statistics from the simulated data are compared for consistency to external projections of aggregate rates of participation in covered employment, in fully insured status, and in male-female earnings differentials. Inconsistent results are handled by making adjustments to the file on a case by case basis. The model developer noted that of all methods of adjustment attempted, this application of expert judgment yielded the best results.

The final data set is used to calculate average future benefits payable to each individual in each year by calculating average benefit amounts

[1]Technical comments on this report provided just prior to publication by the Department of Health and Human Services indicate that revisions to the method were made for the 1986 Trustees Report.

from the sample of earnings histories. These data are then aggregated by beneficiary type. The aggregated statistics are then adjusted to reflect whatever COLAs are projected in the Trustees Report.

The initial data set and the basic model of future benefits is used to make both short and long range projections. The simulations for the two types of forecast are done separately using different sets of assumptions.

Procedures Used to Estimate Taxable Payroll

For the first ten years in the forecast horizon, taxable payroll is estimated by an econometric model developed by the SSA Office of Research, Statistics and International Policy (ORSIP). There was no formal documentation for this model as of the time of our review. However, the developer provided us with a written summary of the general procedures used in the model.

The ORSIP revenue model is a series of separate models, solved in sequential order, to estimate annual, quarterly and subquarterly OASI revenues. Additional model output includes a variety of factors, such as covered wages, that are estimated to produce the final revenue forecasts. Model output is constrained by a variety of assumptions concerning future prices, GNP and other economic variables that are set by the Office of Management and Budget and the social security Board of Trustees.

Some of the model equations are definitional and some conversions of nonprogrammatic variables to programmatic variables are based on judgmentally-determined equations. However, the majority of equations in the model are estimated with regression analysis of time series data. The major exceptions are for variables such as earnings which are estimated cross-sectionally by fitting a curve to actual earnings distribution data and aging the fitted curves. The assumed distributions are more practical than theoretical. (Only in the cases of self-employed earning more than $100,000 is an a priori income distribution assumed.)

The model estimates calendar year taxable earnings for a variety of economic sectors (e.g., federal, private, self-employed), distributes these to quarterly and sub-quarterly time periods, adjusts for lags between accrual of tax liability and payment, and multiplies earnings by appropriate tax rates. Some of the final equations include add factors (a common procedure for time series-based models) to incorporate latest actual experience, allow for structural changes, and reflect constraints on the model solution.

The validity of the revenue forecasts are assessed by backcasting—using the model to predict the recent historical experience. A variety of approaches are used to identify and try to eliminate possible sources of errors, including the use of add factors in some of the equations.

The revenue forecasting model is substantially revised as new data become available. The developer reports that 10-12 substantive changes are made and a large proportion of equations are reestimated every year. These changes result in 4-5 new model versions every year.

For the remainder of the 75-year forecast, taxable payroll is assumed to increase at the compound rate of estimated increases in covered workers and in average covered wages, for estimates made prior to 1985. Beginning in 1985, estimates of taxable payroll after the first ten years of the projection period are produced separately for wage and salary workers, and for the self-employed based on projected future changes in the number of such workers and on projected changes in their productivity, compensation per production and non-taxed fringe benefits.

Simulation Method

Revised versions of the OASDI cost estimate models have been developed over the years to provide forecasts of the effects of various proposed program changes on total program costs. Several were developed for the National Commission on Social Security Reform. Although we refer to these versions as "the revised version" no single model can be identified which was used to develop all of the cost estimates requested by the Commission. An example of how one of the revisions was developed is provided here.

For the long run, the Commission proposal with the biggest impact was the recommended change in the normal retirement age. To evaluate this proposal, the baseline OASDI model was adjusted to allow for a behavioral response to alternative normal ages. This version of the model has two components. The first is the baseline OASDI cost estimate model. The second component makes adjustments in the first model to reflect proposed legislative changes in the OASI program and then calculates savings or increases associated with those changes.

The standard long-range OASDI cost model assumed a slight continuation of the early retirement trend but contained no provisions for substantial behavior changes. The size of the behavioral effects in the revised model were estimated by comparing changes in early retirement ages that would occur if 25 percent of early retirees acted to maintain a constant

benefit level and a smaller portion of early retirees reacted to the rate of return in benefit level for delaying retirement under the proposals compared with that provided under current law. Using the benefit level approach, the proposed reform increases the incentive for delaying retirement while the rate of return perspective slightly decreases this incentive. The additive effects of these two incentives were used to estimate the expected change in retirement rates introduced by the reform proposal. The changed retirement rates were entered as new assumptions in the cost estimate model to determine the financial impact of the proposed changes.

No written documentation was available at the time of our review for the revised model versions.

Model Review

Documentation

Documentation for the long-range OASDI cost estimate model consists largely of a series of actuarial studies published by SSA, each of which describes one component or aspect of the forecasting process. Some aspects of the procedures are not documented at all (e.g., how the initial ten-year revenue projections are made). Although two publications summarized the components of the forecasting process, we found no single document that describes the procedures completely.

As of the end of our data collection period, no documentation existed for the short-range model. However, actuaries responsible for model development and maintenance indicated that this documentation was being written with publication expected sometime in FY86. No plans existed as of 1984 to document the revised model versions which were used to test the effects of program changes.

Maintenance

The short- and long-range models are updated annually to reflect the availability of new data sources, changes in economic and demographic assumptions and changes in relevant laws.

Validity

GAO (1983b) reviewed the integrity of the long-range forecasts produced by SSA during the period 1973-1982 and the accuracy of key economic assumptions used to produce those forecasts. We found that with each

successive year in that period, SSA adjusted its forecasts generally showing an increased actuarial deficit. Errors in the assumptions caused the forecasts to understate benefit costs and overstate trust fund revenues.

Most of the volatility in the forecasts appeared to be caused by the interaction between the automatic benefit increases, tied to cost-of-living increases, and the economy's unfavorable performance. The automatic benefit increase, enacted in 1972, tied the cost of paying benefits directly to cost-of-living increases. Thus, when the cost of living increased as indicated by the consumer price index (CPI), ar. increase in benefits, and in turn, program cost followed automatically. These program costs increased faster than revenues from taxes on earnings and therefore increased the trust fund deficits. As the economy became more erratic, the deficits became more difficult to forecast.

Although the cost forecasts are highly sensitive to errors in economic assumptions, there is no clear guideline for measuring the "acceptability" of the differences between the economic assumptions used in SSA forecasts and the actual economic experience. However, the majority opinion among expert forecasters contacted by GAO, including Chief Actuaries, economists and Fellows of the Society of Actuaries, was that SSA's economic assumptions were generally too optimistic from 1973 through 1982.

The sensitivity of forecasted outcomes to variations in economic assumptions was also demonstrated in a study by Bartlett and Applebaum (1982). They showed that economic forecasting errors as large as those of the early 1970s can produce short-term (five-year) estimates of trust fund balances that differ from actual experience by as much as 40 percent of annual benefit payments.

Legislation which should make future SSA forecasts less sensitive to changing economic factors was passed in the 1977 and 1983 amendments to the Social Security Act. The 1977 amendments minimized the effects of inflationary wages during the workers' recent years of employment by uncoupling the computation of initial benefits from the effects of cost of living increases and computing them on the basis of average monthly indexed earnings, rather than on average monthly earnings. The 1983 amendments provided that the automatic benefit increases be based on either wages or prices, whichever is lower, when the trust funds' balances fall below specified levels.

Sensitivity analyses on selected model assumptions, economic and demographic, are reported in SSA's model documentation. The validity of individual components of the cost estimate models is not documented. For example, there was insufficient detail in the documentation on the labor force simulation model used to develop estimates of benefit levels. This model includes numerous assumptions which vary depending on whether the model is used for short or long range forecasts. Validity information is also not documented for the econometric revenue model.

With respect to forecast accuracy, the annual Trustees Report includes a comparison of actual contributions and benefit payments in the previous fiscal year with those forecasted in the two preceding years.

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Valuation Model of the Civil Service Retirement System (CSRS)

Further information about this model is available from its developer: Office of Personnel Management, 1900 E Street, N.W., Washington, DC 20415.

Background and Use

OPM's valuation model of the CSRS was implemented in 1977 to provide annual reports to the Congress on the financial condition and funding status of the CSRS. The OPM actuaries use it once a year to perform the actuarial calculations needed for the report mandated by P.L. 95-595. Throughout the year, they use it as needed to forecast the effects on program costs of hypothetical legislative and program changes for Congressional and Executive Branch staff. In addition, they use it to generate forecasts for the quinquennial reports of the Board of Actuaries of the Civil Service Retirement System and to develop short- and long-range (100 years) cost estimates for use by the Office of Management and Budget.

The OPM actuaries update the model as needed to reflect changes in law and it is substantially revised every five years for the Board of Actuaries report. Revisions for the 1982 Report have been completed and include changing from a quarterly to an annual forecast horizon and adding length of service as a disaggregation factor for some model rates. There were no major changes to the model.

A revised version of the model was developed by OPM actuaries in 1979 to examine the impact on the CSRS of covering civil service employees under the OASI program for the Universal Coverage Study Group.

Results of this project were used in the Study Group's Final Report and were part of the materials considered by Congress in the enactment of the 1983 Social Security Act amendments.

Model Description

The Valuation Model of the Civil Service Retirement System makes annual forecasts of number of employees, total future salaries, total future annuitants and total future benefits payable to those annuitants. Survivor benefits, refunds and vested benefits for terminated employees electing a deferred annuity are also forecast. These projections form the basis for calculation of annual future revenues and expenses for the CSRS.

Two types of forecast are produced by the model: closed group simulations, which project the future status of current employees and beneficiaries only and open group simulations which include expected future employees in the projection. These forecasts are used for different purposes. The open group simulations are used to project future program costs. However, calculations of the normal cost and the unfunded liability of the CSRS are based on a closed group analysis.

Data Source

The initial data base of current employees is derived from OPM's Central Personnel Data File and information supplied by the Postal Service on postal workers. The initial data base on current retirees is derived from OPM's Compensation Group's records on benefits. These files are updated annually. Forecasts of the profile of new employees are developed from an initial data base on recent new employees which is also derived from the Central Personnel data file and the data on Postal employees. The new employee profile data is updated every five years. The distribution of current new employees is the assumed distribution for all future years in the forecast horizon.

Model Specification

The model simulates annual changes in employee and beneficiary populations by age, sex and years of service. Changes in the size of the employee population are simulated by applying assumed rates of mortality, withdrawal, disability and retirement to the data containing information on present employees. Changes in the annuitant population are simulated by applying rates of death, recovery from disability, and remarriage for survivors. The model assumes a constant workforce size. Each year, new employees are added to replace those who withdrew, died, retired or became disabled. Changes in salaries and benefits are

simulated by applying assumed rates of salary increases for employees and assumed COLAs for beneficiaries.

Calculations of normal cost as a percentage of payroll, using the entry age normal method, reflect interest income earned on invested funds. The assumed interest rate is determined in conjunction with other economic assumptions, such as inflation and salary increases, which affect estimates of the size of the annual payroll.

Assumptions

The demographic assumptions for the model are based on plan experience. Economic assumptions are largely determined by the Board of Actuaries to be consistent with the GAO-OMB reporting requirement which currently requires use of a 5 percent inflation rate. Exceptions are the assumed short-term (first five years) cost-of-living, interest and general salary increases which are based on Office of Management and Budget assumptions, and are used only to calculate the projected flow of plan assets.

Mortality, retirement and withdrawal rates, rates of salary increases, and other economic and demographic assumptions are revised every five years for the Board of Actuaries Report by monitoring the most recent five years' experience to determine present trends and modifying these rates where necessary to reflect expected rates for the future to yield an essentially static set of future rates. Annual changes in some assumptions (short-term economic assumptions for inflation rate, interest rate, and rate of salary increases) are made for the P.L. 95-595 Report.

Some of the models' assumptions are modified when the model is used to examine the effects of proposed changes in the CSRS program. For example, a change which would alter the relationship between the amount of benefits and the age of retirement might affect the future retirement decisions of workers. Retirement rates are therefore adjusted to account for potential behavior changes. New rates are selected by expert judgment to reflect the behavior of employees acting in their financial self-interest.

Model Review

Documentation

Written documentation for the CSRS valuation model consists largely of the annual P.L. 95-595 reports, the quinquennial Board of Actuaries Reports and a narrative description available on request from OPM.

OPM actuaries report that efforts have been made to improve the supplementary documentation of the model. These include maintaining a set of notebooks which contain records of all changes to the model and sample output from all model executions, developing a list of variable definitions, and increasing the number of explanatory comments in the computer code. Records of input files—employee and new entrant files—and model assumptions are also maintained. Some information regarding the model is contained in the annual and quinquennial reports mentioned earlier, and a short narrative description is available on request. Our present model description is based largely on these reports.

Maintenance

The model is updated annually and substantially revised quinquennially. The annual revisions include updating the initial data base on current retirees, revising the model to reflect legislated program changes and other maintenance activities as needed. The quinquennial revisions include all of the above plus updating the new employee profile and determining all new demographic rates and economic assumptions based on recent experience.

The developers report that proposed changes to the valuation program are discussed by three retirement actuaries and all three verify the accuracy of implemented changes.

Validity

GAO (1982d) reviewed the reliability of the financial and actuarial information included in the 1980 annual report on the Civil Service Retirement System, including projections based on the Valuation Model of the CSRS. The focus of that review was primarily data validity and management control over operations. Several weaknesses in these factors were identified. However, with respect to operational validity, our review at that time showed that the actuarial assumptions used in OPM's model were reasonable, and tests of the primary data base on program participants disclosed no significant problems. In our more recent review of their 1984 annual report (GAO, 1986b), we examined the computer

implementation of the model as part of our review and concluded that the financial statements presented fairly the financial status of the CSRS.

Model developers currently report that they conduct sensitivity analyses on the model's assumptions every five years for the Board of Actuaries Report. In particular, they examine the variation in forecasts that is introduced by changing assumptions used in the past report to current estimates. The tested assumptions include withdrawal, salary scale, disability, retirement and mortality rates, and all individual economic assumptions. In addition they annually examine the accuracy of the previous year's forecast for the current year and try to identify possible sources of error. They also monitor similar cost projections produced by OPM's budget group for consistency with their own forecasts.

When estimates are made of the costs of proposed changes to the CSRS, the reasonableness of outcomes, compared to baseline and alternative proposal outcomes, is used as an additional method for checking the logic used in the models.

Other reliability checks include the forecasts generated by other models of the CSRS—those developed by the Congressional Research Service and Towers, Perrin, Forster and Crosby.

References

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OFFICE OF PERSONNEL MANAGEMENT. Board of Actuaries of the Civil Service Retirement System Fifty-Seventh Annual Report. Washington, D.C.: U.S. Government Printing Office, 1980.

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Gorgo—Long-Run Valuation Model of the Military Retirement System

Further information about this model is available from its developer: Office of the Actuary, Department of Defense (DOD) Manpower Data Center, 1600 N. Wilson Blvd., Suite 400, Arlington, VA 22209-2593.

Background and Use

GORGO was developed in 1980 by the Office of the Actuary of the Defense Manpower Data Center to make long-run projections of retired pay and normal cost for the Military Retirement System. It has been revised annually since then to reflect changes in the law, changes in economic and demographic assumptions and some methodological changes. The most recent revision of the model was completed in the spring of 1985 and was used to generate FY86 forecasts.

The model's forecasts of normal cost, expressed as a percentage of basic pay, are used to make trust fund allocations for the Department of Defense budget. In addition, model results are reported annually to the Congress and GAO as mandated by P.L. 95-595.

Model Description

Data Sources

Initial accounting figures on population size and pay as of the end of the prior fiscal year, disaggregated by beneficiary and active duty status, serve as input to the model. The four military personnel centers (Army, Navy, Marines, and Air Force) provided data on active duty personnel and the four Service Finance Centers provided data on retirees and survivors. These data were supplemented with data on Reserve forces contained in the Reserve Component Common Personnel Data System.

Model Specification

The model forecasts cost of the Military Retirement System using both open and closed group simulations. The forecast horizon is 100 years. Results from the closed group simulations are used to estimate the unfunded liability (the present value of future benefits minus the present value of normal costs for those currently in the system). Results from the closed group simulation are also used to calculate a normal cost percentage. The latter percentage is calculated by dividing the present value of future benefits by the present value of future salaries of a new entrant group, assumed to enter the program on the valuation date.

Other model outputs include the number of active duty personnel (regular and non-regular by officer/enlisted status) and active duty gross pay, the number of retirees and retiree pay, both disaggregated by disability status, officer/enlisted status and reserve retirements. Disaggregations by sex are not done at all and disaggregations by age are not a routine model output.

There are numerous subroutines in the model for calculating benefits. These include benefits for ordinary retirees, reserve retirees, and survivors.

Values for economic assumptions other than the inflation rate have in the past been selected to be consistent with assumption differentials recommended by the Board of Actuaries of the Civil Service Retirement System. Currently these assumptions are set by the DOD Retirement Board of Actuaries. The inflation rate was to be consistent with that requested by the Office of Management and Budget and GAO. For the 1984 valuation, the inflation rate was 5 percent. Rates for wage growth (not including merit and promotion) and investment return were 6.2 and 6.6 percent, respectively.

An ongoing effort is devoted to estimating the demographic assumptions used by the model. These assumptions include rates of death, temporary retirement disability, nondisability retirement, withdrawal, reentry and transfers in status. Estimation methods for each rate vary and include various curve-fitting procedures. Separate mortality tables are used developed for disabled and nondisabled retirees. For the latter group, mortality rates are assumed to improve over time. Improvement rates were developed from the II-B mortality assumptions of the Social Security Administration. The rates differ in that GORGO uses a uni-sex mortality improvement assumption.

Model Review

Documentation

The model documentation includes information on the past accuracy of the model's demographic assumptions and a description and justification of the procedures used to correct for past errors. Justification for the

choice of other assumptions and the method of analysis are also provided. The model documentation also includes an explanation of the procedures used to ensure that the starting data sources were reasonably accurate.

Validity

GAO (1982b) completed a review of the Department of Defense's fiscal 1980 financial and actuarial statements relating to the Military Retirement System. Part of this review included analysis of the techniques, formulae, assumptions and computer program logic used in the first version of GORGO to generate the actuarial forecasts for that year. We concluded that these features of GORGO were satisfactory to produce reasonable forecasts.

Some revisions to GORGO have been made since that time, particularly on the methods used to estimate various demographic assumptions. These are described in the model documentation. The model developer reports that sensitivity analyses are conducted but are not a routine feature of the model.

A peer review of the model was completed in early 1985 by an independent actuary who concluded that it was constructed according to generally accepted actuarial standards.

References

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GAO (U.S. General Accounting Office). The Results of Our Initial Review of the Financial and Actuarial Statements Submitted Pursuant to Public Law 95-595, AFMD-82-67. Washington, D.C.: May 21, 1982b.

Valuation Model for the Foreign Service Retirement and Disability System

Further information about this model is available from its sponsor: Director, Office of Employee Relations, Department of State, 2201 C St., N.W., Washington, DC 20520.

Background and Use

The model for the Foreign Service plan, located at the Department of Treasury, is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the Foreign Service Retirement System covered 11,419 active employees, 6,434 retiree annuitants, 1,482 other annuitants, and 218 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending September 30, 1983, using the entry age normal method for calculating normal cost. Reported economic assumptions include inflation rate (5 percent), rate of return (6 percent), and a salary increase assumption (5.5 percent). Reported demographic assumptions include mortality, disability, and withdrawal (all based on plan experience 1979-82).

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

In 1983, GAO reviewed the program's internal controls for the 1982 fiscal year. These controls can affect the quality of input data (data validity) and the detection of errors. Several weaknesses in these controls were identified.

References

GAO (U.S. General Accounting Office). Review of Fiscal Year 1982 Financial Transactions of the Foreign Service Retirement and Disability System, B-164292. Washington, D.C.: August 18, 1983a.

U.S. DEPARTMENT OF STATE. "Foreign Service Retirement and Disability System Annual Report for FY 1983 as Required by Section 121 of

the Budget and Accounting Procedures Act of 1950." Washington, D.C.: n.d.

Valuation Model for the Judicial Retirement System and Judicial Survivors' Annuities System

Further information about this model is available from its sponsor: The Federal Judiciary, Administrative Office of the United States Courts, Export-Import Bank Building, 811 Vermont Avenue, N.W., Washington, DC 20005.

Background and Use

The model for the Judicial Retirement System and the Judicial Survivors Annuity System is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the former system covered 668 active employees, 223 retiree annuitants, and 17 other annuitants, and the latter, 676 active participants, and 209 survivor annuitants. The 676 active participants in the latter plan include the active employees of the former plan as well as some annuitants of that plan.

Model Description

Our description is based on the report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the entry age normal method for calculating normal cost, and the valuation for the survivors system was done using the aggregate method. Economic assumptions include inflation (5 percent), rate of return (7 percent), and a salary increase assumption (5.5 percent, which includes five percent inflation rate). Demographic assumptions include mortality (1971 Group Annuity Mortality Table for Males and Females), disability (.5 percent per year), and retirement. No withdrawal is assumed. The Survivors Annuity System is prefunded, while the Retirement System is not.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference	ADMINISTRATIVE OFFICE OF THE UNITED STATES COURTS. "Reports of the Financial Condition of the Judicial Retirement System and the Judicial Survivors' Annuities System for the Year Ended December 31, 1983, Pursuant to the Provisions of P.L. 95-595." Washington, D.C.: n.d.

Valuation Model for the United States Tax Court Retirement Plan and Survivors' Annuity Plans

Further information about this model is available from its sponsor: Chief Judge, United States Tax Court, 400 Second Street, N.W., Washington, DC 20217.

Background and Use

The model for the United States Tax Court Plans is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the former plan covered 14 active employees and 11 retiree annuitants; the latter, 3 survivor annuitants and 17 active participants (including active employees and some annuitants from the former plan).

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the entry age normal method for calculating normal cost. Reported economic assumptions include inflation (5 percent), rate of return (7 percent) and salary increase (5.5 percent which includes a five percent inflation component). Reported demographic assumptions include mortality (1971 Group Annuity Mortality Tables for Males and Females), disability (.5 percent per year), retirement (age 70). No withdrawal is assumed. The Survivors Annuity System is prefunded, while the Retirement System is not.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference	U.S. TAX COURT. "Actuarial Reports Required Under P.L. 95-595 for the U.S. Tax Court Judges' Retirement and Survivor Annuity Plans for the Year Ending December 31, 1983." Washington, D.C.: n.d.

Valuation Model for the Public Health Service Commissioned Corps Retirement System

Further information about this model is available from its sponsor: Public Health Service, Department of Health and Human Services, 5600 Fishers Lane, Rockville, MD 20857.

Background and Use

The model for the Public Health Service Plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 5,586 active employees, 1,765 retiree annuitants, and 455 other annuitants.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending September 30, 1983, using the aggregate entry age normal method for calculating normal cost. The model is programmed in PVL (pension valuation language), a proprietary language of Hay Associates. Reported economic assumptions include inflation (5 percent), rate of return (6 percent), and salary increase (5.5 percent). Reported demographic assumptions include mortality (based on 1977-1980 rates used for officers of the Military Retirement System), withdrawal (based on PHS plan experience), and retirement.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference	PUBLIC HEALTH SERVICE. "Chapter 95 of Title 31, U.S. Code Report for the PHS Commissioned Corps Retirement System for the Plan Year Ending September 30, 1983." Rockville, Md.: n.d.

Valuation Model for the National Oceanic and Atmospheric Administration Corps Retirement System

Further information about this model is available from its sponsor: National Oceanic and Atmospheric Administration, 6010 Executive Blvd., Rockville, MD 20852.

Background and Use	The model for the National Oceanic and Atmospheric Administration Plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 375 active employees, 109 retiree annuitants, and 58 other annuitants.
Model Description	Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending September 30, 1983, using the aggregate entry age normal method for calculating normal cost. The model is programmed in PVL (pension valuation language), a proprietary language of Hay Associates. Reported economic assumptions include inflation (5 percent), rate of return (6 percent), and salary increase (5.5 percent). Demographic assumptions include mortality and withdrawal (both based on the experience of officers in the Military Retirement System), and retirement.
Model Review	Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference	NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION. "1983 NOAA Corps Pension Plan Report as Required under P.L. 95-595." Rockville, Md.: n.d.

Valuation Model for the Coast Guard Military Retirement System

Further information about this model is available from its sponsor: Commandant (G-FPS), United States Coast Guard, 2100 Second Street, S.W., Washington, DC 20593.

Background and Use	The model of the Coast Guard Military Retirement System is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 39,253 active duty employees, 12,156 reserve duty employees, 20,594 retirees, and 1,910 other annuitants.
Model Description	Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending September 30, 1983, using the entry age normal method for calculating normal cost. Reported economic assumptions include inflation (5 percent), rate of return (6 percent), and salary increase (5.5 percent). Reported demographic assumptions include mortality (1971 Group Annuity Mortality Table), withdrawal (based on Department of Defense experience), and retirement.
Model Review	Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.
Reference	U.S. COAST GUARD. "Report on the Coast Guard Military Retirement System as of September 30, 1983, as Required by Public Law 95-595." Washington, D.C.: n.d.

Valuation Model for the TVA Retirement System[2]

Further information about this model is available from its sponsor: Chairman, TVA Retirement System Board of Directors, Tennessee Valley Authority, 400 Summit Hill Drive, Knoxville, TN 37902.

Background and Use

The model for the Tennessee Valley Authority plan is used to provide financial information for annual reports required under P.L. 95-595. As of 1983, the plan covered 24,828 active employees, 683 separated employees entitled to deferred benefits, and 7,322 retiree annuitants.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending September 30, 1983, using the unit credit method for calculating normal cost. The reported economic assumptions include inflation (5 percent), rate of return (7.5 percent), and salary increase (5.5 percent, graded by age). Reported demographic assumptions include mortality (1971 Group Annuity Table, rated back one year, and a special table for disability retirement), withdrawal (based on plan experience), and retirement.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

TENNESSEE VALLEY AUTHORITY. "The TVA Retirement System's Annual Report Required by 31 U.S.C. 9501-9504 (1982) for Plan Years Ending September 30, 1980, and September 30, 1983." Knoxville, Tenn.: n.d.

[2]The plan name was recently changed from the Retirement System of the Tennessee Valley Authority to the one given.

Valuation Model for the Navy Resale and Services Support Office Retirement Plan

Further information about this model is available from its sponsor: Navy Resale and Services Support Office, P.O. Box 129, Fort Wadsworth, Staten Island, NY 10305-5097.[3]

Background and Use

The model for the Navy Resale and Services Support plan is used to provide financial data for annual reports required under P.L. 95-595. The plan is a multiple employer plan covering 3 employers: 1) The Naval Resale and Services Support Office, 2) The Naval Military Personnel Command, and 3) The U.S. Coast Guard Resale Program. As of 1983, it covered 14,512 active employees (9,112 employer 1, 5,036 employer 2, and 364 employer 3), 3,787 retirees (3,219 employer 1, 521 employer 2, and 47 employer 3), 254 other annuitants (183 employer 1, 68 employer 2, and 3 employer 3), and 420 separated employees entitled to deferred benefits (374 employer 1, 37 employer 2, and 9 employer 3).

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the entry age normal method for calculating normal cost. Reported economic assumptions include inflation (5 percent), rate of return (8 percent), and salary increase (7 percent). Reported demographic assumptions include mortality (1971 Group Annuity Mortality table, set back 6 years for females), withdrawal (based on a table developed by the Wyatt Company), and retirement (age 61). The developer indicated that demographic assumptions are made for spouses based on the 1962 Railroad Retirement Board Death and Remarriage Tables.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

[3]The address given is that of the plan. The names and addresses of individual employer sponsors are as follows: Navy Resale and Services Support Office, Risk Management Branch, Building 208, Ft. Wadsworth, Staten Island, NY 10305 for the two Resale plans; Naval Military Personnel Command, Employee Benefits Section, Recreational Services Division, Washington, DC 20370 for the Navy Personnel plan.

Reference	NAVY RESALE AND SERVICES SUPPORT OFFICE. "Navy Resale and Services Support Office Retirement Plan, Financial Statements and Schedules, December 31, 1983." Staten Island, N.Y.: n.d.

Valuation Model for the US Army Nonappropriated Fund Employee Retirement Plan

Further information about this model is available from its sponsor: Program Manager, US Army Morale, Welfare and Recreation Fund, P.O. Box 107, Arlington, VA 22210-0107.

Background and Use

The model for the Army Nonappropriated Fund plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 11,831 active employees, 1389 retiree annuitants and 4 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending September 30, 1983, using the entry age normal method for calculating normal cost. Reported economic assumptions include rate of return on investment (7.5 percent); the inflation rate, in relation to plan provisions for post retirement benefit adjustments, is not relevant as adjustments are made on an ad hoc basis. Reported demographic assumptions include mortality (table published by Towers, Perrin, Forster and Crosby), withdrawal, and retirement. The developer indicated that disability assumptions are used, but these are not reported.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

In 1982, GAO audited the plan report for 1980 (GAO, 1982b). Such an audit can reveal weaknesses in internal control or reporting methods which can affect data quality and operational validity. GAO discovered

several reporting problems, one of which resulted from inconsistent use of assumptions.

References

GAO (U.S. General Accounting Office). The Results of Our Initial Review of the Financial and Actuarial Statements Submitted Pursuant to Public Law 95-595, AFMD-82-67. Washington, D.C.: May 21, 1982b.

U.S. ARMY MORALE, WELFARE AND RECREATION FUND. "Report of the U.S. Army Nonappropriated Fund (NAF) Employee Retirement Plan for the Period Ending September 30, 1983, as Required by P.L. 95-595." Arlington, Va.: n.d.

Valuation Model for the Retirement Plan for Civilian Employees of United States Marine Corps Exchanges, Recreation Funds, Clubs, Messes, and the Marine Corps Exchange Service

Further information about this model is available from its sponsor: Commandant of the Marine Corps (LFE), Headquarters, U.S. Marine Corps, Washington, DC 20380.

Background and Use

The model for the Marine Corps Exchange plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 3,199 active employees, 0 retirees, 39 other annuitants, and 1,015 separated employees entitled to deferred benefits.[4]

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the Entry Age Normal method for calculating normal cost. Reported economic assumptions include inflation (5 percent), rate of

[4]619 retiree annuitants were excluded from the reported number of retirees because annuities for these retirees have been previously purchased under an insured contract.

return (7.5 percent), and salary increase (6.5 percent). Reported demographic assumptions include mortality (1971 Group Annuity Mortality table, set back 6 years for females), withdrawal (Aetna's Turnover 70, adjusted for disablement rates), and retirement.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

COMMANDANT OF THE MARINE CORPS. "1983 Annual Report of the Retirement Plan for Civilian Employees of the United States Marine Corps Exchanges, Recreation Funds, Clubs, Messes, and the Marine Corps Exchange Service, as Required Under P.L. 95-595." Washington, D.C.: n.d.

Valuation Model for the US Air Force Nonappropriated Fund Retirement Plan for Civilian Employees

Further information about this model is available from its sponsor: Department of the Air Force Welfare Board, Randolph Air Force Base, TX 78150.

Background and Use

The model for the Air Force Nonappropriated Fund plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 5,412 active employees, 718 retirees 35 other annuitants, and 329 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending September 30, 1983, using the Entry Age Normal method for calculating normal cost. Reported economic assumptions include inflation (5 percent), rate of return (7 percent), and salary increase (7 percent). Reported demographic assumptions include mortality (1971 Group Annuity Mortality

table), withdrawal (based on a Wyatt Company table) and retirement (age 63). The developer indicated that disability (Railroad Retirement Board 12 Valuation rates) assumptions, and assumptions for spouses (1962 Railroad Retirement Board Death and Remarriage Tables), were made, but these were not reported.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are partially analyzed in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

DEPARTMENT OF THE AIR FORCE WELFARE BOARD. "Annual Report on the Air Force Nonappropriated Fund (AFNAF) Retirement Plan for Civilian Employees as Required Under P.L. 95-595 For the Plan Year Ending 30 Sep 83." Randolph Air Force Base, Tex.: n.d.

Valuation Model for the Retirement Annuity Plan for Employees of Army and Air Force Exchange Services[5]

Further information about this model is available from its sponsor: Assistant Comptroller-Insurance, Departments of the Army and the Air Force, Headquarters, Army and Air Force Exchange Service, Dallas, TX 75222.

Background and Use

The model for the Army and Air Force Exchange plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 23,870 active employees, 7,860 retirees, 432 other annuitants, and 781 separated employees entitled to deferred benefits.

[5]Members of the Executive Management Program are also covered under a Supplemental Deferred Compensation Plan. The Supplemental Plan covers 931 active employees, 718 retirees and 49 other annuitants. The valuation for the 1983 plan year report was made December 31, 1983. The Supplemental Plan uses the same economic and demographic assumptions as the regular plan, except for different withdrawal assumptions also developed by the Wyatt Company, and a different retirement assumption (age 59 on average, or after 5 years of service if later).

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the Entry Age Normal method for calculating normal cost. Reported economic assumptions include inflation (5 percent), rate of return (8 percent), salary increase (7 percent), and increase in the social security wage base (5.5 percent). Reported demographic assumptions include mortality (1971 Group Annuity Mortality table, set back 2 years for males and 8 years for females), spouse's benefits (1962 Railroad Retirement Board Death and Remarriage Tables), disability (based on Civil Service experience), withdrawal (based on a Wyatt Company table), and retirement (age 60 on average, or after five years of service if later).

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

DEPARTMENTS OF THE ARMY AND THE AIR FORCE, HEADQUARTERS. "Annual Report of the Army and Air Force Exchange Service on the Financial Conditions of Its Pension Plans for the Year Ended December 31, 1983, per P.L. 95-595." Dallas, Tex.: n.d.

Valuation Model for the Norfolk Naval Shipyard Pension Plan

Further information about this model is available from its sponsor: General Manager, Norfolk Naval Shipyard Co-Operative Association, Portsmouth, VA 23709.

Background and Use

The model for the Norfolk Naval Shipyard Pension Plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 69 active employees (plus 10 non-contributing employees), 28 retirees, and 1 separated employee entitled to deferred benefits.

Model Description

Our description is based on the annual report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the aggregate method for calculating normal cost. Reported economic assumptions include inflation (5 percent), salary increase (8.5 percent to age 40 and 7 percent thereafter) and rate of return (8 percent). Reported demographic assumptions include mortality (1951 Group Annuity table, projected to 1964 by Scale C and set back 6 years for females), withdrawal (Sarason T-3 table in the Actuary's Pension Handbook, Crocker-Sarason-Straight, 1955 edition), and retirement.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

NORFOLK NAVAL SHIPYARD. "Annual Report of the Norfolk Naval Shipyard Pension Plan for the 1983 Plan Year as Required Under P.L. 95-595." Portsmouth, Va, n.d.

Valuation Model for the US Navy Nonappropriated Fund Retirement Plan for Employees of Civilian Morale, Welfare and Recreation Activities

Further information about this model is available from its sponsor: Navy Nonappropriated Fund Activities, c/o Civilian Personnel Policy Division, Dept. of the Navy, Washington, DC 20350.

Background and Use

The model for the Navy Nonappropriated Fund Plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 85 active employees, and no retirees or other annuitants (the plan was established in October 1982).

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the entry age normal method for calculating normal cost. Reported economic assumptions inflation (5 percent), rate of return (8 percent), salary increase (7 percent), and an increase in the social security wage base (5.5 percent). Reported demographic assumptions include mortality (1971 Group Annuity Mortality table set back 6 years for females), withdrawal (Wyatt Company table), disability (Railroad Retirement Board 12th Valuation Rates of Disability), spouse's pensions (1962 Railroad Retirement Board Death and Remarriage Tables), and retirement (age 63 on average).

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Some tables are not included because the plan conducts a valuation every other year, and for 1983 no valuation was done. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

NAVY NONAPPROPRIATED FUND ACTIVITIES. "Annual Report of the U.S. Navy Nonappropriated Fund Retirement Plan for Employees of Civilian Morale, Welfare and Recreation Activities for the 1983 Plan Year as Required Under P.L. 95-595." Washington, D.C.: n.d.

Valuation Model for the Retirement Plan for Employees of the Federal Reserve System

Further information about this model is available from its sponsor: The Board of Governors of the Federal Reserve System, Washington, DC 20551.

Background and Use

The model for the Federal Reserve Plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 24,682 active employees, 7,747 retiree annuitants, 1,085 other annuitants, and 1,888 separated employees entitled to deferred benefits.

Model Description	Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the Entry Age Normal method for calculating normal cost. Reported economic assumptions include inflation (5 percent) and rate of return (7.5 percent). Demographic assumptions include mortality (1951 Group Annuity table), and withdrawal (based on plan experience). Another valuation is done with a different set of assumptions.
Model Review	Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.
Reference	BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM. "Annual Report of the Retirement Plan for Employees of the Federal Reserve System for the 1983 Plan Year as Required Under P.L. 95-595." Washington, D.C.: n.d.

Valuation Model for the Federal Home Loan Mortgage Corporation Employees' Pension Plan

Further information is available about this model from its sponsor: Vice President Human Resources, Federal Home Loan Mortgage Corporation, 1776 G Street, N.W., P.O. Box 37248, Washington, DC 20013.

Background and Use	The model for the Federal Home Loan Mortgage plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 430 active employees, 4 retirees, and 102 separated employees entitled to deferred benefits.
Model Description	Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the unit credit method for calculating normal cost and is written in PVL (pension valuation language), a proprietary language of

Hay Associates. Reported economic assumptions include rate of return (8 percent); inflation is not relevant for the valuation since benefits are not indexed. Reported demographic assumptions include mortality (1971 Male Group Annuity Mortality table, set back six years for females) and withdrawal (table T-5 less Ga 51 male).

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has stated that generally accepted actuarial principles and practices were used to prepare the financial statement. No other validity information is provided in the model documentation.

Reference

FEDERAL HOME LOAN MORTGAGE CORPORATION. "Annual Report of the Federal Home Loan Mortgage Corporation for the 1983 Plan Year as Required Under P.L. 95-595." Washington, D.C.: n.d.

Valuation Model for the Farm Credit District of Baltimore Retirement Plan

Further information about this model is available from its sponsor: Federal Land Bank of Baltimore, P.O. Box 1555, Baltimore, MD 21203.

Background and Use

The model of the Baltimore Farm Credit plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 885 active employees, 92 retirees, 10 other annuitants, and 61 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the entry age normal method for calculating normal cost. Reported economic assumptions include rate of return (9 percent); inflation is not relevant for the valuation because benefits are not indexed. Reported demographic assumptions include mortality (UP-1984 Mortality Table), withdrawal (Wyatt Company Multiple Service tables, based on plan experience), and retirement.

Model Review	Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.
Reference	FEDERAL LAND BANK OF BALTIMORE. "Annual Report of the Farm Credit District of Baltimore Retirement Plan for the Year Ending December 31, 1983 as Required by P.L. 95-595." Baltimore, Md.: n.d.

Valuation Model for the Eighth Farm Credit District Retirement Plan

Further information about this model is available from its sponsor: Plan Administrator, Eighth Farm Credit District Employee Benefit Trust, Farm Credit Banks of Omaha, 206 South 19th Street, Omaha, NE 68102.

Background and Use	The model for the Eighth Farm Credit District is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 1,997 active employees, 164 retirees, and 301 separated employees entitled to deferred benefits.
Model Description	Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the frozen initial liability method for calculating normal cost. Reported economic assumptions include inflation (5 percent), and rate of return (7.5 percent) and salary scale (6 percent). Reported demographic assumptions include mortality (1971 Group Annuity table for males with projection, Bankers Life modification, set back 6 years for females), withdrawal (table 7, The Actuary's Pension Handbook), and retirement (normal retirement age as defined by plan).
Model Review	Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not

explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

FARM CREDIT BANKS OF OMAHA. "Annual Report of the Eighth Farm Credit District Retirement Plan for the 1983 Plan Year as Required by P.L. 95-595." Omaha, Neb.: n.d.

Valuation Model for the Farm Credit Banks of Texas Pension Plan

Further information about this model is available from its sponsor: Plan Committee for Farm Credit Banks of Texas Plan, Texas Bank for Cooperatives, P.O. Box 15919, Austin, TX 78761.

Background and Use

The model for the Texas Farm Credit Banks plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 723 active employees, 154 retirees, 3 other annuitants, and 121 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the entry age normal method for calculating normal cost. Reported economic assumptions include rate of return (6.5 percent); inflation is not reported as benefits are not indexed. Reported demographic assumptions include mortality (1971 Group Annuity table), withdrawal (Scale T-5 according to Crocker, Sarason and Straight turnover rates), and retirement.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference	TEXAS BANK FOR COOPERATIVES. "Annual Report of the Farm Credit Banks of Texas Pension Plan for the Plan Year Ended December 31, 1983, in compliance with P.L. 95-595." Austin, Tex.: n.d.

Valuation Model for the Twelfth District Farm Credit Retirement Plan

Further information about this model is available from its sponsor: Plan Administrator, Farm Credit Banks, TAF C-5, Spokane, WA 99220.

Background and Use	The model for the Twelfth Farm Credit District plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 1,119 active employees, 160 retirees, 21 other annuitants and 42 separated employees entitled to deferred benefits.
Model Description	Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the entry age normal method for calculating normal cost. Reported economic assumptions include rate of return (8 percent); inflation is not relevant as benefits are not indexed. Reported demographic assumptions include mortality (1983 Group Annuity Mortality table), withdrawal (Tables T-3 and T-8 in the Actuary's Pension Handbook), and retirement.
Model Review	Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.
Reference	FARM CREDIT BANKS OF THE TWELFTH DISTRICT. "Annual Report of the Twelfth District Farm Credit Retirement Plan for the 1983 Plan Year as Required Under P.L. 95-595." Spokane, Wash.: n.d.

Valuation Model for the Retirement Plan for the Employees of the Seventh Farm Credit District

Further information about this model is available from its sponsor: Seventh Farm Credit District, 375 Jackson Street, St. Paul, MN 55101.

Background and Use

The model for the Seventh Farm Credit District plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 2,543 active employees, 155 retirees, 6 other annuitants and 116 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the entry age normal method for calculating normal cost. Reported economic assumptions include rate of return (6.5 percent) and inflation (5 percent). Reported demographic assumptions include mortality (1984 Unisex Table, set back one year), withdrawal, and retirement.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

SEVENTH FARM CREDIT DISTRICT. "Annual Report of the Retirement Plan for the Employees of the Seventh Farm Credit District for the 1983 Plan Year as Required by P.L. 95-595." St. Paul, Minn.: n.d.

Valuation Model for the Retirement Plan for the Employees of the Associations and Banks of the Ninth Farm Credit District

Further information about this model is available from its sponsor: Chairman of the Trust Committee, The Ninth Farm Credit District, 151 North Main, Wichita, KS 67202.

Background and Use

The model for the Ninth Farm Credit District plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 1,076 active employees, 152 retirees, 30 other annuitants and 113 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending February 28, 1983, using the frozen initial liability method for calculating normal cost. Reported economic assumptions include inflation (greater than 3 percent), and rate of return (8 percent). Reported demographic assumptions include mortality (1971 Group Annuity table, projected by Projection Scale D to 1975 with rates set back 6 years for females), withdrawal and retirement.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

NINTH FARM CREDIT DISTRICT. "Statement of General Information for the Retirement Plan for Employees of the Associations and Banks of the Ninth Credit District for the Plan Year Ending February 28, 1983, as Required Under P.L. 95-595." Wichita, Kan.: n.d.

Valuation Model for the Farm Credit Retirement Plan—Fifth Farm Credit District

Further information about this model is available from its sponsor: Farm Credit Banks of Jackson, P.O. Box 16610, Jackson, MS 39236-0610.

Background and Use

The model for the Fifth Farm Credit District plan (formerly named the New Orleans District) is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 503 active employees, 59 retirees, and 68 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the frozen initial liability method for calculating normal cost. Reported economic assumptions include rate of return (6 percent, 13.66 percent for those retired prior to January 1, 1984); inflation rate assumption is not relevant as benefits are not indexed. Reported economic assumptions include mortality (1971 Group Annuity Mortality table, set back 6 years for females), withdrawal, and retirement (age 64).

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

FARM CREDIT BANKS OF JACKSON. "Annual Pension Plan Report for the Farm Credit Retirement System - Fifth Farm Credit District for the 1983 Plan Year as Required Under P.L. 95-595." Jackson, Miss.: n.d.

Valuation Model for the Production Credit Associations Retirement Plan—Fifth Farm Credit District

Further information about this model is available from its sponsor: Production Credit Associations - Fifth Farm Credit District, P.O. Box 16610, Jackson, MS 39236-0610.

Background and Use

The model of the Production Credit Associations of the Fifth Farm Credit District retirement plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 403 active employees, 131 retirees, and 73 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the frozen initial liability method for calculating normal cost. Reported economic assumptions include rate of return (6 percent, 13.69 percent for all retired prior to January 1, 1984); inflation is not relevant as benefits are not indexed. Reported demographic assumptions include mortality (1971 Group Annuity Mortality table, set back 6 years for females), withdrawal, and retirement (age 64).

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

PRODUCTION CREDIT ASSOCIATIONS. Fifth Farm Credit District. "Annual Report of the Production Credit Associations' Retirement Plan - Fifth Farm Credit District, for the 1983 Plan Year as Required Under P.L. 95-595." Jackson, Miss.: n.d.

Valuation Model for the Sacramento Farm Credit Employees' Retirement Plan

Further information about this model is available from its sponsor: Farm Credit Banks of Sacramento, 3636 American River Drive, Sacramento, CA 95825.

Background and Use

The model of the Sacramento Farm Credit retirement plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 1,002 active employees, 170 retirees, 18 other annuitants, and 131 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31 1983, using the frozen initial liability method for calculating normal cost. Reported economic assumptions include rate of return (8 percent), and salary increase (8 percent); the inflation rate is not relevant as benefits are not indexed. Reported demographic assumptions include mortality (1971 Group Annuity Mortality table, set back 6 years for females), withdrawal (based on a New York Life table derived from tables T-2 and T-8 from the Actuaries Handbook), and retirement.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

FARM CREDIT BANKS OF SACRAMENTO. "Sacramento Farm Credit Employees' Retirement Plan: Public Law 95-595 Annual Report for 1983 to the Comptroller General and the Congress of the United States." Sacramento, Calif.: n.d.

Valuation Model for the Sixth Farm Credit District Retirement Plan

Further information about this model is available from its sponsor: Sixth Farm Credit District Retirement Plan Trust Committee, P.O. Box 504, St. Louis, MO 63166.

Background and Use

The model of the Sixth Farm Credit District plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 1,605 active employees, 211 retirees, 20 other annuitants (terminated due to disability with a deferred benefit), and 121 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, using the frozen initial liability method for calculating normal cost. Reported economic assumptions include rate of return (7.5 percent), inflation (3 percent for those previously retired prior to 5/1/74, 5 percent for the calculation of the Social Security projection that is used in one of the benefit formulas). Reported demographic assumptions include mortality (1971 Male Group Annuity Mortality table, set back 6 years for females), withdrawal (based on table T-4 from the Actuary's Pension Handbook, modified for females), and retirement.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. No validity information is provided in the model documentation.

Reference

FARM CREDIT BANKS OF ST. LOUIS. "Annual Report of the Sixth Farm Credit District Retirement Plan for the 1983 Plan Year as Required by P.L. 95-595." St. Louis, Mo.: n.d.

Valuation Model for the Group Retirement Plan for Federal Land Bank Associations, Production Credit Associations and Farm Credit Banks in the First Farm Credit District

Further information about this model is available from its sponsor: Group Retirement Plan for Federal Land Bank Associations, Production Credit Associations and Farm Credit Banks in the First Farm Credit District, P.O. Box 141, Springfield, MA 01101.

Background and Use

The model for the First Farm Credit District plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 727 active employees, 102 retirees, and 79 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending March 31, 1983, using the frozen initial liability method for calculating normal cost. Reported economic assumptions include rate of return (7 percent), and salary increase (graded from 9.9 percent at age 20 to 7 percent at age 35, and 4 percent at age 60); inflation is not relevant as benefits are not indexed. Reported demographic assumptions include mortality (TPF&C Forecast Mortality table), withdrawal (based on plan experience), and retirement.

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

FARM CREDIT BANKS OF SPRINGFIELD. "Annual Report of the Farm Credit Banks of Springfield Retirement Plan for the Plan Year Ending March 31, 1983 as Required under P.L. 95-595." Springfield, Mass.: n.d.

Valuation Model for the Farm Credit Institutions in the Fourth District 1979 Amended Retirement Plan

Further information about this model is available from its sponsor: Trustees of Farm Credit Institutions in the Fourth District, Retirement Trust, P.O. Box 32660, Louisville, KY 40232.

Background and Use

The model of the Fourth Farm Credit District retirement plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 2,321 active employees, 320 retirees, 15 other annuitants, and 275 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year. The valuation was done for the period ending December 31, 1983, (one table is presented with the valuation done as of January 1, 1984), using the frozen initial liability method for calculating normal cost. Reported economic assumptions include rate of return (6 percent for the calculation of annual cost, and 7 percent for the calculation of accumulated plan benefits); inflation is not relevant as benefits are not indexed. Demographic assumptions include mortality (1971 Group Annuity Mortality table for Males, set back 6 years for females), withdrawal (table T-5 in the Actuary's Handbook), and retirement (age 65).

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. An enrolled actuary has certified that the methods and assumptions are reasonable. No other validity information is provided in the model documentation.

Reference

TRUSTEES OF FARM CREDIT INSTITUTIONS IN THE FOURTH DISTRICT. "Annual Report of the Farm Credit Institutions in the Fourth District Amended Retirement Plan for the 1983 Plan Year as Required by P.L. 95-595." Louisville, Ky.: n.d.

Valuation Model for the Farm Credit Retirement Plan—Columbia District

Further information about this model is available from its sponsor: The Federal Land Bank of Columbia, Post Office Box 1499, Columbia, SC 29202.

Background and Use

The model for the Columbia Farm Credit District plan is used to provide financial data for annual reports required under P.L. 95-595. As of 1983, the plan covered 1,709 active employees, 169 retirees, 9 other annuitants, and 90 separated employees entitled to deferred benefits.

Model Description

Our description is based on the annual P.L. 95-595 report for the 1983 plan year with the valuation as of August 31, 1983, using the entry age normal and individual premium methods for calculating normal cost. Reported economic assumptions include rate of return (7 percent); inflation is not relevant as benefits are not indexed. Reported demographic assumptions include mortality (1971 Group Annuity Mortality table), withdrawal (table T-5, Crocker, Sarason, and Straight, applied to nonvested benefits only).

Model Review

Model documentation includes summary information on the plan and its participants, actuarial assumptions and methods, description of plan provisions, and financial statements. Actuarial gains and losses are not explicitly reported in the documentation. No other validity information is provided in the model documentation.

Reference

FEDERAL LAND BANK OF COLUMBIA. "Annual Report of the Farm Credit Retirement Plan - Columbia District - for the 1983 Plan Year, as Required Under P.L. 95-595." Columbia, S.C.: n.d.

Appendix III

Models of Civilian Retirement Decision Behavior

In this appendix we describe 35 empirically estimated models of retirement decision behavior. Most of these models were developed to estimate the relationship between the availability and amount of social security benefits and the retirement decisions of workers. Many of these models can produce estimates of what changes in retirement decisions would be expected if benefits were increased or decreased and they can predict the effects on retirement of changes in worker characteristics, such as income or health.

Over one-third of the 35 models have been applied in policy experiments, including backcasts of the effects of 1969 and 1972 social security benefit increases on retirement behavior and forecasts of the effects of various private pension and social security policy changes.

Model descriptions are based on the structure presented in appendix 1. Thirty-four of the descriptions were reviewed for accuracy by the model developer(s) and all identified errors were corrected. For one model, the Pellechio labor force participation model, we received no response from the developer to our request for review. A summary of the individual model descriptions is provided in the main volume of this report. There, we refer to individual models by identification numbers. These numbers are provided in table III.1 for cross-referencing.

Table III.1: Identification of Decision-Models

Model	ID number[a]	Page
Anderson-Burkhauser lfp[b] health model	20	62
Anderson et al. retirement plans model	25	63
Barker-Clark lfp model	7	64
Boskin lfp model	2	66
Boskin-Hurd ba[c]-lfp model	4	68
Burkhauser ba-lfp model of auto workers	1	69
Burkhauser ba OASDI model	8	70
Burkhauser-Quinn lfp model	13	71
Burtless lfp model	26	75
Burtless-Hausman ba-lfp model of federal civil servants	9	77
Burtless-Moffitt lfp model	27	80
Clark et al. joint lfp model	10	83
Diamond-Hausman hazard model	28	85
Diamond-Hausman probit lfp model of the unemployed	29	87
Diamond-Hausman competing risks lfp model of the unemployed	30	88
Fields-Mitchell age of lfp model	21	90
Gohmann-Clark age of ba model	31	92
Gohmann-Clark lfp model	32	93
Gordon-Blinder lfp model	11	95
Gustafson lfp model	16	97
Gustman-Steinmeier reduced form model	14	100
Gustman-Steinmeier structural model	22	102
Hamermesh lfp model	17	105
Hausman-Wise Brownian motion lfp model	33	107
Hausman-Wise hazard model	34	109
Henretta-O'Rand lfp model of women	12	112
Honig-Hanoch lfp model	23	113
Hurd-Boskin lfp model	15	116
Kutner age of ba/lfp model of California educators	35	119
Mitchell-Fields age of ba model/ordered logit ba model	24	121
O'Rand-Henretta age of retirement model	18	123
Pellechio lfp model	5	124
Quinn lfp model	3	126
Schmitt-McCune ba-lfp model of Michigan civil servants	6	128
Slade lfp model	19	130

[a]Model identification numbers correspond with ones used in chapter 2 of the main volume of this report.

[b]Labor force participation (lfp)

[c]Benefit acceptance (ba)

Anderson-Burkhauser Model

Background and Use

The Anderson-Burkhauser model was developed in 1983 to estimate the interaction between health and retirement. The model has not been used for policy experiments or forecasting. Further information is available from its developers: Kathryn Anderson and Richard V. Burkhauser, Department of Economics, Vanderbilt University, Nashville, TN 37235.

Model Description

Data Source

The model was estimated on a sample of 4878 male respondents to the 1969 RHS for whom 1979 mortality information was also available. These men were aged 58-63 in 1969.

Model Specification

A multivariate logistic procedure was used to estimate the effects of various factors jointly on retirement and health. The model was estimated using two different measures of health— self-reported health status and actual mortality experience. Retirement was defined as labor force withdrawal in 1969.

Non-economic predictors of retirement included marital status, age, race, children and a work-health interaction factor. Economic predictors included housing wealth, wages, and a retirement wealth variable which was a combination of social security and private pension wealth.

Model Review

The model documentation included standard errors for each predictor. No summary measure of overall model validity was provided.

The model has not been used for policy experimentation or forecasting. It is unique in modeling retirement and mortality as jointly determined events. A major weakness of the model with respect to replicating its results on new samples is that it requires data on actual mortality experience. The developer does not recommend its use for forecasting.

Reference

ANDERSON, K. H., and R. V. Burkhauser. "A Jointly Determined Retirement Decision Model: The Interaction of Health and Work Choice." Vanderbilt University, Nashville, Tenn., n.d.

Anderson et al. Model

Background and Use

The Anderson et al. model was developed to examine the relationship between retirement plans and actual retirement behavior. The model has not been used for policy experimentation or forecasting. Further information is available from its developers: Kathryn Anderson and Richard Burkhauser, Department of Economics, Vanderbilt University, Nashville, TN 37235, and Joseph F. Quinn, Department of Economics, Boston College, Chestnut Hill, MA 02167.

Model Description

Data Source

The model was estimated on a sample of 1,580 male, non-self-employed workers who were aged 58 to 63 and in the labor force in 1969. All were respondents to the 1969-1979 RHS and were living in 1979.

Model Specification

For this model, retirement was defined by self-assessed status as either keeping house, retired or unable to work. The outcome variable was the probability of being in one of three categories: retired according to plans stated in 1969, retired earlier than planned and retired later than planned. Group membership was estimated with a multi-nominal logit procedure as a function of several predictors.

Institutional predictors included job tenure, presence of a mandatory retirement provision on the job, and private pension coverage. Change variables included the change in 1969 social security wealth associated with benefit rules in effect in the planned retirement year, whether the planned retirement year was after the 1973 change in the earnings test, health changes in the two years preceding planned or actual retirement, and the difference between 1969 local unemployment levels and levels in the planned or actual retirement year. A final predictor was the number of years between present age (in 1969) and the planned retirement age.

A second specification of the model was estimated deleting the earnings test variable with comparable results.

Model Review

No information on overall model validity was provided. However, standard errors and significance tests for individual predictors were included in the model documentation.

The model has not been used for policy experimentation or forecasting. Rather, it can be viewed as an attempt to identify and test the importance of unexpected changes in determining the difference between planned and actual retirement ages.

Reference

ANDERSON, K. H., R. V. Burkhauser, and J. F. Quinn. "Do Retirement Dreams Come True? The Effect of Unexpected Events on Retirement Age." Vanderbilt University, Nashville, Tenn., 1984.

Barker-Clark Model

Background and Use

The Barker-Clark model was developed to assess the effects of mandatory retirement provisions on the labor force participation of older men. Results from the model were used to estimate the impact of the 1978 Age Discrimination in Employment Act amendments which raised the allowable mandatory retirement age to 70. Further information is available from its developer: David T. Barker, Department of Economics, George Fox College, Newberg, OR 97132, and Robert L. Clark, Department of Economics and Business, North Carolina State University, P.O. Box 5368, Raleigh, NC 27650.

Model Description

Data Source

The model was estimated on a sample of 1394 white male wage earners who were respondents to the 1969 RHS and were aged 62-63 in 1969 (version A). The model was re-estimated first on the subsample of 1024 of those workers who also responded to the 1971 (version B) RHS and were thus aged 64-65 in 1971 and again on the subsample of 944

workers who responded to the 1973 RHS and were thus aged 66-67 in that year (version C).

Model Specification

Logit analysis procedures were used to estimate this single equation model which assesses the effects of economic and non-economic factors on the labor force participation (work versus retirement) decisions of white males.

Economic variables included social security wealth, private pension wealth, private pension eligibility, imputed wage rate, asset income, home value, and spouse's labor force status and wage. The effect of mandatory retirement rules was assessed through the inclusion of two variables—whether mandatory retirement was required on the current job at age 65 and whether it was required at some age greater than 65.

Non-economic variables included marital status, numbers and types of dependents (adult, children) area of residence (rural, urban), employment in the public or private sector and presence of mild or greater health limitations. Additional variables, such as job tenure, were assumed to affect the retirement decision through their effects on the worker's wage.

Simulation Method

Indirect effects of mandatory retirement rules were estimated from a wage equation developed on this sample of workers which included mandatory retirement rules as a predictor. The change in wages associated with mandatory retirement rules for a hypothetical worker with average job tenure was multiplied by the estimated effect of wage changes on the retirement decision to determine indirect effects for workers of different ages. These results were summed with the model's estimates of direct effects of mandatory retirement rules to determine total effects of these rules on retirement. These results were then multiplied by the percentage of workers in the labor force covered by mandatory retirement rules (and therefore directly affected by the proposed changes in the allowable mandatory retirement age) to estimate the effects of policy change on the total labor force participation rates.

Model Review

The likelihood value associated with the model and summaries of significance tests for the predictors were included in the documentation. The developer reported estimating the model on other demographic groups, including women and minorities, with less than satisfactory results.

Details on these estimations were not provided in the model's documentation.

The focus of this model was assessing the effects of mandatory retirement rules on labor force participation. It was useful for simulating the effects of policy changes enacted in the 1978 Age Discrimination in Employment Act Amendments. However, no time course in which the effects would be expected to be observed was specified, making it difficult to assess how well the model accounts for post-1978 labor force trends.

Reference

BARKER, D. T., and R. L. Clark. "Mandatory Retirement and Labor-Force Participation of Respondents in the Retirement History Study." Social Security Bulletin, 43:11 (1980), 1-11.

Boskin Model

Background and Use

The Boskin Markov chain[1] model was developed in 1977 to assess the effects of social security on retirement patterns. The model takes advantage of longitudinal data to model retirement as a continuous time process. The model has not been used for policy experimentation or forecasting. Further information is available from its developer: Michael J. Boskin, Department of Economics, Stanford University, Stanford, CA 94305.

Model Description

Data Source

The estimation sample consisted of 131 white married males, aged 61-65 in 1968, who were respondents to the 1968-1972 PSID. Observations from all five years were included in the model estimation.

[1]A Markov chain is a sequence of movements among various states, where the probability of changing from one state to another or remaining in the same state depends on the current state. In retirement, the states are various labor force participation categories, such as full retirement, partial retirement, and working fulltime. Movements among states are observed annually and the probabilities of the movements are estimated across individuals using the Markov chain model.

Model Specification

In this model, retirement was defined as working less than quarter-time. Quasi-retirement was defined as working less than half-time (or earning less than half of full-time pay on the previous job). Two versions of the model were estimated. In the first version, retirement was defined as a choice between two states—working or retired. In the second version, retirement was defined as a choice among three states, the above two plus quasi-retirement. The model estimates the probability of retirement as a function of a set of predictors using a multi-state Markov chain model. The model was estimated using multinomial logistic methods.

Predictors in the model included net earnings, social security benefits, income from assets, spouse's earnings and a variable reflecting whether or not the respondent was age 65 (a variable which reflects eligibility for full social security benefits or potential eligibility for other pension benefits that set normal retirement at age 65). Health was included as a predictor in the two-state model.

Two additional estimations of the two-state model were made. In one, social security benefits and asset income were summed to reflect a single income effect variable. This model version did a poorer job of explaining retirement than the basic model. The second version deleted the health variable and included an age 62 factor (reflecting eligibility for early retirement), education and a set of variables reflecting the year in which each observation was taken. The estimated effects from this model were comparable to those in the basic model.

Model Review

Model likelihood values and standard errors for each predictor were included in the model documentation.

The model developer reported estimating the same model on several different outcome variables: less than half-time work, less than one-tenth time work and self-assessed retirement status with similar results. These results were not reported in the documentation. Results from the model pertaining to income characteristics were theoretically plausible.

This model has not been used for policy experimentation or forecasting. Rather it can be viewed as an early attempt to model the continuous time nature of retirement. Since it was based on a very small sample (131 men) relative to other models, replication of results on a larger sample would enhance confidence in the model's validity for possible future use.

Reference

BOSKIN, M. J. "Social Security and Retirement Decisions." Economic Inquiry, 15 (1977), 1-25.

Boskin-Hurd Model

Background and Use

The Boskin-Hurd model was developed in 1978 to estimate the effects of social security on the early retirement decision. It has not been used for policy experimentation or forecasting and there are no current plans for such use. Further information is available from its developers: Michael J. Boskin, Department of Economics, Stanford University, Stanford, CA 94305, and Michael D. Hurd, Department of Economics, State University of New York, Stony Brook, NY 11794.

Model Description

Data Source

The estimation sample consisted of approximately 1,000 white males aged 60-68 in 1969 who were respondents to the 1969 and 1971 RHS. All were working in 1969, none had working spouses, and none were receiving welfare income. The exact sample size used for the estimation was not reported.

Model Specification

Retirement was defined as not working. Partial retirement was defined as working and receiving social security benefits. Two equations were estimated using a nonlinear logistic estimation procedure. One equation solves for the probability of retiring in 1971 (conditional on working in 1969) and the second solves for the probability of accepting social security benefits but continuing to work in 1971.

Predictors included gross and net wages, annual household social security benefits, nonwage income, age, health, presence of a spouse or dependents, and presence of mandatory retirement rules on the present job.

Model Review

Model validity measures were not reported in the model documentation although standard errors for individual predictors were provided.

This model is one of the earliest models of the retirement decisions and should be viewed as an exploratory study of the effects of various predictors on retirement. We question the usefulness of the results since all of the workers in the model were aged 65 or less and many could potentially retire early in subsequent years, a problem acknowledged by the developer. (These developers have estimated a more recent model which does not have this problem. See the entry for Hurd-Boskin.)

Reference

BOSKIN, M. J. and M. D. Hurd. "The Effect of Social Security on Early Retirement." Journal of Public Economics, 10:3 (1978), 361-77.

Burkhauser Model of Auto Workers

Background and Use

The Burkhauser model of private pension benefit acceptance was developed in 1976 and revised in 1978 to estimate the effects of changes in private pension wealth on the decision to accept pension benefits prior to age 65. The model has not been used for forecasting or public policy experimentation. Further information is available from its developer: Richard V. Burkhauser, Department of Economics, Vanderbilt University, Nashville, TN 37235.

Model Description

Data Source

The sample used in this study consisted of 761 male Michigan automobile workers, aged 59-64 in 1965 who were eligible for an early United Auto Workers' pension. The model was estimated on the entire sample and then separately for 630 healthy workers and 131 workers in ill-health. A final estimate of the model was done on 326 of the original sample who were resampled in 1967 and were aged 61-64 at that time.

Model Specification

The model was estimated using three different regression procedures—ordinary least squares, probit and logit analyses. The results were fairly consistent across all three procedures. The model defines retirement as acceptance of the UAW pension and leaving the main job.

Factors influencing this decision included age, wage, health and marital status, non-pension financial assets, the present value of future earnings and the difference in pension wealth that is associated with delaying the retirement decision until age 65.

Model Review

Likelihood values for the probit and logit model estimations were reported in the documentation. No overall model validity measure was provided for the ordinary least squares regression estimation (although a standard measure - R^2 would be appropriate). Tests of the significance of individual predictors were provided for all three estimation procedures.

This model has not been used for forecasting or policy experimentation and the model developer does not recommend such use. The model has limited generalizability focusing solely on a geographically and occupationally restricted sample—Michigan auto workers.

Reference

BURKHAUSER, R. V. "The Pension Acceptance Decision of Older Men." Journal of Human Resources, 14 (1979), 63-75.

Burkhauser OASDI Model

Background and Use

The Burkhauser model of early social security benefit acceptance was developed in 1980 to test the importance of social security wealth on the decision to accept social security benefits. Further information is available from its developer: Richard V. Burkhauser, Department of Economics, Vanderbilt University, Nashville, TN 37235.

The developer has no plans to update or revise this particular model. However, a highly similar model was developed by Burkhauser and Quinn in 1981. The latter model is described in more detail in the next inventory entry.

Model Description

Data Source

The model was estimated on a sample of 713 62-63 year-old male respondents to the March 1973 CPS whose responses were matched to Social Security Administration earnings records. All men were eligible to receive social security benefits at age 62 (version A). A re-estimate of the model was made on 636 of those men who also were working in OASDI-covered employment at age 61 (version B).

Model Specification

For this model, retirement was defined as accepting social security benefits. It was measured by categorizing respondents in one of two groups: those who accepted benefits at age 62 and others.

Probit analysis procedures were used to estimate the effects of education, marital status, market earnings, eligibility for private pensions, and social security wealth on the early benefit acceptance decision of workers.

Model Review

The model documentation included the likelihood values associated with the two model equations and statistical tests for each predictor.

The model has not been used for forecasting or policy experimentation and the model developer does not recommend such use.

Reference

BURKHAUSER, R. V. "The Early Acceptance of Social Security: An Asset Maximization Approach." Industrial and Labor Relations Review, 33:4 (1980), 484-92.

Burkhauser-Quinn Model

Background and Use

The Burkhauser-Quinn model was developed in 1981 to study the effects of mandatory retirement rules on job transitions and withdrawal from the labor force. It was revised and extended to provide a retirement decision module for DYNASIM, a microsimulation model described in

appendix IV. A final revision of the original model was completed in 1983. There are no current plans by the developers to update or further revise the model. Further information is available from its developers: Richard V. Burkhauser, Department of Economics, Vanderbilt University, Nashville, TN 37235 and Joseph F. Quinn, Department of Economics, Boston College, Chestnut Hill, MA 02167.

The original model was used to simulate what job transition behavior for those facing mandatory retirement rules on the job would have been had those rules not been in effect.

The DYNASIM version of the model was used in conjunction with other DYNASIM modules to forecast retirement patterns in the year 2000 under alternative retirement policies. Results from these forecasts were included in a Department of Labor Report to the Congress on the likely effects on retirement of the 1978 Age Discrimination in Employment Act Amendments which raised the age limit for mandatory retirement rules. In addition to this application, all forecasts generated by DYNASIM since 1981 have been based in part on results from the model. Examples of these forecasts are described in appendix IV.

The DYNASIM version of the model has not been updated or revised since 1981 and there are no present plans by DYNASIM developers to further update or revise it.

Model Description

Data Source

All versions of the Burkhauser-Quinn model were estimated on samples of respondents from the RHS. The original version of the model was estimated on six samples of men and three samples of women. The male samples (versions A, B, D, E, G and H) were partitioned by age (three categories) and by self employment status (two categories). The women, who were all single, were partitioned into three age category groupings (versions C, F and I), corresponding to the same age category groupings used for men. Due to smaller available sample sizes, the women were not separated into self-employment status categories. Observations for respondents at ages 58-61 were taken from the 1969 and 1971 RHS. Observations for respondents in the other two age groups were taken from the 1973 and 1975 RHS. The samples are not all independent of one another. For example, some of the workers who were aged 62-65 in 1969

were included in the sample of workers aged 62-65 in 1973. Sample sizes ranged from a low of 256 single females aged 65-67 to a high of 2812 non-self-employed males aged 58-61. The 1983 revision of the model (version P) was estimated for a single group of non-self employed males aged 62-64. The sample size for this estimate was 921. The sample is somewhat smaller than the original sample used to develop estimates for this group of men due to the deletion in the revised model of government employees.

The estimations of the model for the DYNASIM module were based on similar but not identical samples. Only six samples were used, sorted by sex and three age groupings: 58-61 (versions J, K), 62-64 (versions L, M), and 65-67 (versions N, O). Separate estimations by self employment status were not done. The sample sizes used in the DYNASIM estimations were not reported in that model's documentation.

Model Specification

For this model, retirement was defined as withdrawal from the labor force. The model estimates changes in labor force participation that occurred during a two-year transition period—1969-71 or 1973-75, depending on the sample used in the estimation. The model consists of two equations which are estimated independently for each of the subgroups described above. The first equation estimates the probability of a worker leaving the main job in the transition period. The second equation estimates the probability that workers who left their main job will take a new job or retire during the transition period. Model equations were estimated using logit analysis procedures.

The original and revised versions of the model and the model version developed for use in DYNASIM include a similar set of factors used as predictors of labor force behavior. The primary difference in versions is that more predictors are included in the DYNASIM version than in the others. Factors used in the basic model are described first and then the additions for the DYNASIM version are given.

Eight factors are used to explain the first decision—leaving the main job. Six factors are used to explain the second decision—taking a new job or retiring. Five of these factors appear in both equations: 1) the presence of mandatory retirement rules on the present job which would affect the worker in the future, 2) social security wealth, 3) private pension wealth, 4) marital status, and 5) self-assessment of the presence of a recent health deterioration.

The three unique factors affecting the decision to leave the main job are 1) the prior year's earnings, 2) changes in social security wealth that would occur if retirement were delayed for one more year and 3) changes that would occur in private pension wealth if retirement were delayed for one more year. The unique factor in the estimation of the decision to retire completely after leaving the main job is the worker's market wage rate. This wage rate was calculated for each worker by using standard human capital equations for white and blue collar workers which reflect the average wage paid in the market for a given worker's characteristics.

The version of the model developed for DYNASIM uses 13 predictors of the decision to leave the main job. The additional five variables reflect social security and private pension eligibility status. This version uses eight factors to predict the subsequent decision to take a new job or retire. The two additional factors are ones that were used in the first equation—changes in social security and private pension wealth that would occur if retirement were delayed another year. Also, the DYNASIM version replaced the subjective measure of health with disability status.

Simulation Methods

The model was used to estimate the effects of removing mandatory retirement rules on retirement behavior. This was done by applying the model to a sample of workers who were facing mandatory retirement rules in the transition period and estimating what their transition behavior would be under the assumption that such rules were absent. The difference between their predicted behavior and their actual behavior was interpreted as the maximum effect of mandatory retirement rules on retirement behavior.

For the forecasts produced by DYNASIM, the Burkhauser-Quinn model is applied only to workers who are not facing mandatory retirement rules as a two-stage decision model. In the first stage, the model calculates the probability that a worker will leave the main job. A random number is then drawn and if it is greater than the estimated probability, the worker is assigned continued working status for the remainder of that year. Otherwise, the worker is assumed to leave the main job. For the latter workers, the model calculates the probability of retiring. This probability is compared to a random number to project retirement status for that worker. The model is applied in this two-stage manner every two years in the simulation period after a worker reaches age 58 until he reaches age 70. The final output of the simulation includes the year and age at which retirees are predicted to withdraw from the labor force.

Model Review

No validity information was provided in the documentation for the DYNASIM version of the model. Model and predictor validity statistics were provided for other model estimations.

This model is unique in the class of models of the retirement decision because it has been used repeatedly in DYNASIM forecasts. This continued use is somewhat questionable given that the equations for women were based on unmarried women approaching retirement age in the late 1960s and early 1970s but are being applied to the general female population. Thus DYNASIM forecasts of future retirement trends of women may have substantial error. Likewise, the model outcome variable is labor force participation but the model in DYNASIM is used to simulate benefit acceptance. This is an additional source of forecast error. We know of no reasons, other than historical ones, to prefer this model over other models of the retirement decision for use in large-scale micro-simulation models.

References

BURKHAUSER, R. V., and J. F. Quinn. "Is Mandatory Retirement Overrated? Evidence from the 1970s." Journal of Human Resources, 18:3 (1983), 337-58.

URBAN INSTITUTE. Mandatory Retirement Study: The Effects of Raising the Age Limit for Mandatory Retirement in the Age Discrimination in Employment Act. Washington, D.C.: Urban Institute, 1981.

Burtless Model

Background and Use

The Burtless model is a structural model of retirement age developed in 1984 and used to simulate the short-run and long-run effects of the unexpected social security benefit increases in 1969 and 1972 on the timing of retirement. Further information is available from its developer: Gary Burtless, The Brookings Institution, 1775 Massachusetts Avenue, N.W., Washington, DC 20036.

The model developer has no immediate plans to update or revise the model or to use it to study potential reforms to the Social Security system.

Model Description

Data Source

The sample used to estimate the model consisted of 4193 male respondents, aged 58-63 in 1969 to the 1969 RHS. Observations through the 1979 wave of the RHS were included to determine the age of retirement for these men. The age of retirement for non-retirees was treated as a censored variable using modern statistical methods; non-retirees were consequently used in the empirical estimation. The sample excluded farmers, women, disabled men, men who retired prior to age 55, welfare recipients, and recipients of federal or railroad retirement pensions.

Model Specification

For this model, retirement was defined as the first discontinuous drop in hours worked to a level below 30 hours per week. The outcome variable estimated by the model is the age at which retirement occurred. The model is a structural model which yields estimates of the effects of hypothetical constructs on retirement age. The constructs are derived from economic theory and are measured by combining information from several observed variables.

The model estimates the effects on retirement of health, marital status, family wealth, household size, the subjective rate of discounting income received after age 71 (a factor which the model solves for rather than specifies), the rate of growth of lifetime income, the level of lifetime wealth (both in 1969 and imputed wealth from future social security entitlements), and divergence from retirement plans.

The effects of private pension assets are included in the family wealth variable through calculation of the present discounted value of private pension benefits. The effects of social security benefits on retirement age are included in the income and wealth growth rates.

Simulation Method

Microsimulations of the effects on retirement age of historically different social security benefit formulae were conducted by assigning workers in the estimation sample the benefits implied by each formula and then using the model to compute the implied retirement ages. Both short-run and long-run effects were estimated by varying the year in which the proposed policy change took effect. The long-run simulations

were based on policy changes taking place in 1955. The short-run simulations were based on policy changes occurring in 1969 or in 1969 and 1972.

Model Review

This model was used to backcast the effects of 1969 and 1972 benefit increases using the microsimulation procedure described above. The model predicted a short-run (1969-1979) decline in full labor force participation by age 65 of 1.5 percent. This number could have been compared to the actual decline observed in that period as part of the model validation, although the developer did not make such a comparison.

The model documentation contains the likelihood value associated with the model and standard errors for each of the predictors, statistics that are indicators of the model's validity. Results from the model were theoretically reasonable.

This model has not been used for forecasting. It has been used for backcasting—predicting the behavioral response to past social security policy changes. It was also used for policy experimentation—predicting what the behavioral response would be to the availability of increased benefits. The model could be used for similar types of simulations of both long and short run effects but at present there are no plans for such use.

Reference

BURTLESS, G. Social Security, Unanticipated Benefit Increases, and the Timing of Retirement. Washington, D.C.: The Brookings Institution, 1984.

Burtless-Hausman Model

Background and Use

The Burtless-Hausman model (1982) was developed in 1980 to study the combined effects of social security and civil service pensions on government employees' retirement decisions. The model distinguishes between federal retirees who draw civil service pension benefits and supply labor outside the government and those who draw benefits and withdraw labor supply. Further information is available from its developers:

Gary Burtless, The Brookings Institution, 1775 Massachusetts Ave., N.W., Washington, DC 20036, and Jerry A. Hausman, Department of Economics, Massachusetts Institute of Technology, E52-271A, Cambridge, MA 02139.

The model was used to simulate the short-term (one to two year) retirement behavior response of males to policy changes that would (1) change the age requirement for federal pension receipt, and (2) change the social security benefit formula to reduce unintended subsidies to federal workers who have dual entitlements. The simulations were done for the Universal Social Security Coverage Study Group, a panel commissioned by the Congress to investigate the interaction between government pensions and social security. The final report of the Study Group (March 1980) was relied upon by the National Commission on Social Security Reform in making recommendations concerning civil servants which led to the enactment of the 1983 amendments to the Social Security Act.

The model has not been revised or reestimated since its original development and the developers have no plans for update.

Model Description

Data Source

The Burtless-Hausman model was estimated separately on samples of 3116 males and 1040 females who were working for the federal government in 1976. These workers constitute a one percent sample of federal employees whose federal employment and pension records were matched to social security earnings and benefit records in a non-public administrative data file.

Model Specification

The model was estimated by using 1976 worker characteristics to explain 1977 labor force behavior. Labor force status was classified as working for the federal government, accepting a federal pension and taking a job in the private sector or accepting a pension and withdrawing from the labor force. The effects of worker characteristics on the decision to choose one of these three "states" was estimated with covariance probit procedures.

Age was the only non-economic characteristic included in the model. All economic characteristics were measured in ratio form. These include the ratio of present wages to wages three years earlier, the wage replacement rate of the federal pension (the ratio of pension entitlement to 1977 wage), the wage replacement rate of social security benefits, the change in the social security replacement rate that would occur if the individual took a job in the private sector, the social security replacement rate multiplied by years to eligibility for social security, and the federal pension replacement rate multiplied by years to eligibility for the federal pension. Curvilinear terms for the last two factors were also included in the model.

Simulation Method

Microsimulations of the effects of policy changes on worker's behavior were performed by altering individual financial characteristics to reflect the proposed policy changes and using the estimated model to calculate the probability for each individual of selecting one of the three possible outcomes given their new characteristics. These probabilities were then summed across individuals to yield the number of individuals in the sample who are expected to have chosen each outcome. These numbers are compared to pre-change estimates of choice to determine the proportion of individuals who were expected to change their choice as a consequence of the policy change.

Model Review

Validity

Likelihood values for the equations and standard errors for each predictor were included in the model documentation. Results for men and women were qualitatively similar. The developer reported that an alternative specification of the model using values of potential pensions in nonratio form was estimated. Results from that specification were not provided in the documentation. The developer noted, however, that its empirical validity was lower than that of the model described in this entry.

The developer also noted that the simulation method selected for the policy experiments is associated with smaller prediction variability for finite samples than the alternative procedure of random assignment to retirement "states" employed in large microsimulation models, like DYNASIM. (Refer to appendix IV of this volume and chapter 4 of the main

volume for a more complete discussion of the microsimulation approach.)

Use

This model is unique in that it models the retirement behavior of federal employees. Its policy experiment results were useful for estimating short-run effects on retirement behavior. (The developer noted that the results were only valid for the sample examined and for short-term projections. Long-term forecasts would be unreliable). A model of this type might be a useful addition to the Civil Service Retirement System Valuation model (see appendix II) which currently uses expert judgment to calculate the effects of proposed policy changes on retirement patterns. The model has not been used or re-estimated since its initial development and there are no current plans for revisions.

Reference

BURTLESS, G., and J. Hausman. " 'Double Dipping': The Combined Effects of Social Security and Civil Service Pensions on Employee Retirement." Journal of Public Economics, 18:2 (1982), 139-59.

Burtless-Moffitt Model

Background and Use

The Burtless-Moffitt model was developed in 1984 to assess the effects of social security on retirement age and post-retirement labor supply. It was used to simulate the effects of raising the normal retirement age, reducing benefits, increasing the incentives to delay retirement and eliminating the retirement earnings tests. The model results have not been officially used although Burtless (1984) used them as a basis for invited testimony before the House Joint Economic Committee. Further information is available from its developers: Gary Burtless, The Brookings Institution, 1775 Massachusetts Ave., N.W., Washington, DC 20036, and Robert A. Moffitt, Department of Economics, Rutgers University, New Brunswick, NJ 08903.

The model developers have no plans to update or revise the model or to do additional simulations on proposed reforms to the Social Security program.

Model Description

Data Source

The sample used to estimate this model consisted of 4612 men aged 58-63 in 1969 who were respondents to the 1969 RHS. Those men who had not retired by 1969 were observed on subsequent RHS data surveys through 1977. The sample excluded women, disabled men, farmers, men who had retired prior to age 55, the very wealthy and the very poor and recipients of railroad retirement or federal pensions.

Model Specification

In this model, retirement was defined as the first observed discontinuous drop in hours worked to a level below 30 hours per week. The model jointly estimates two outcome variables—the age at which the drop in work hours occurred and the number of work hours reported in the RHS survey immediately following retirement.

The model is a structural model which yields estimates of the effects of hypothetical constructs on retirement age. The constructs are derived from economic theory and are measured by combining information from various observed variables. The estimation procedure—a nonlinear maximum likelihood method— yields two equations which are solved simultaneously. The first equation models post-retirement work effort as a function of education, marital status, post-retirement wage rate and weekly retirement income flow. The last variable in this function is a weighted combination of non-wage income from savings and income flow from social security benefits. The model solves for, rather than specifies, the weight that social security benefits carry relative to other income sources and allows the relative weight given to these benefits to change as a function of age.

The second equation models the age of retirement as a function of age, health, race, education, vesting in a private pension plan and the subjective rate of discounting future income (a factor that the model also solves for rather than specifies). Future income streams include changes in social security benefits and private income flows that would occur if retirement were delayed one year. Changes in private income flows were determined by estimating a pre-retirement net savings rate for each person in the sample. An hourly wage for post-retirement work was also estimated and included as a factor in the calculations.

Simulation Method	The model was used to conduct policy experiments by first estimating the age of retirement for three theoretically representative workers with fixed earnings histories. Three alternative reforms to the social security benefit formula were used to recalculate potential social security benefits for these workers. The model was then applied to the representative workers using the hypothetical benefits to estimate retirement age. Any changes in estimated retirement age from the basic model estimation reflect the potential impact of the benefit formula reforms.

Model Review

Validity	The likelihood value for the model and standard errors for each construct in both equations were reported in the model documentation. The developers reported that selection of predictors for the model was based in part on results from ordinary least squares models of the two outcome variables. Results from these models were not provided in the documentation. A brief critique of the model by S. Rosen, focusing on its theoretical validity, was published in the model documentation (Burtless and Moffitt, 1984). Rosen commented that successful use of the model to simulate the observed recent decline in labor force participation rates would add considerably to an assessment of the model's validity.
Use	This model is useful for conducting social security policy experiments, focusing on short-run effects of program changes. The developers suggest that simulation results have limited generalizability since the model specification does not account for any changes in private pension income or savings that might result from social security benefit changes. The developer noted that a limitation of the model with respect to use is that it is extremely complicated and somewhat expensive to use for simulation.

Reference

BURTLESS, G., and R. A. Moffitt. "The Effect of Social Security Benefits on the Labor Supply of the Aged." In H. J. Aaron and G. Burtless (eds.),

Retirement and Economic Behavior. Washington, D.C.: The Brookings Institution, 1984.

Clark et al. Model

Background and Use

The Clark et al. model was developed in 1980 to estimate the effects of family characteristics on the joint labor force participation decisions of husband and wife. Results from the model have not been officially used although Clark has used them in testimony before several Congressional committees. The model has not been used for forecasting or policy experimentation. Clark is continuing to revise this and related models by expanding the pension and social security variables. Further information is available from its developers: Robert L. Clark, Thomas Johnson, and Ann Archibald McDermed, Department of Economics and Business, North Carolina State University, P.O. Box 5368, Raleigh, NC 27650.

Model Description

Data Source

The sample used in the original model estimation (version A) consisted of 3,312 non-self-employed married men aged 58-63 in 1969 who were respondents to the 1969 RHS and whose spouses were present in the home. The model was re-estimated for the subsample of 2170 men who responded to the 1971 RHS (version B) and for the subsample of 2174 who responded to the 1973 RHS (version C).

Model Specification

The retirement decision was defined in the model as the joint and simultaneous decisions of husband and wife to participate or withdraw from the labor force. The same set of factors was assumed to affect the husband's and wife's decisions. The model was estimated with multivariate logistic procedures.

Family variables included in the model were primarily economic ones: home equity, assets, welfare income, husband's disability income, and number and type of dependents (adult, children) in the home.

Personal economic variables of the husband and of the wife were assumed to affect each person's decision. Thus, the wages, current eligibility for and wealth of social security, and private pension benefits of each partner were included in the model.

Husband and wife's age were both included in the model. Although the theoretical model specified inclusion of the health status of both partners, the estimated model only included the husband's health. Information on the wife's health was unavailable. Finally the retirement decision of the husband was assumed to affect that of the wife and vice versa. Thus the model included a variable which reflected the spouse's decision.

The final model yielded two equations using the same set of predictors—one for the wife's decision and one for the husband's decision.

Model Review

The likelihood value for the model and tests of the significance of individual predictors for each equation were reported in the documentation. The qualitative results for the three estimations were comparable. Results were theoretically plausible.

This model has not been used for policy experimentation or forecasting. Rather, it can be viewed as a demonstration of empirical support for the inclusion of spouse characteristics in models of the retirement decision.

Reference

CLARK, R. L., T. Johnson, and A. A. McDermed. "Allocation of Time and Resources by Married Couples Approaching Retirement." Social Security Bulletin, 43:4 (1980), 3-16.

Diamond-Hausman Hazard Model

Background and Use

The Diamond-Hausman hazard model[2] was developed to study the effects on retirement patterns of changes in the age of eligibility for social security benefits. It was used to examine the effects of eliminating the availability of social security benefits to those under the age of 65 and changing the normal retirement age to 68 with early retirement benefits available at ages 65 through 67. Further information is available from its developers: Peter A. Diamond and Jerry A. Hausman, Department of Economics, Massachusetts Institute of Technology, E52-271A, Cambridge, MA 02139.

The original model was developed in 1983 under partial sponsorship of the National Commission on Social Security Reform. It was updated in 1984 to take advantage of the availability of additional survey data.

In addition to the simulations described above, the original model was used as input to a model of wealth accumulation developed by Diamond and Hausman.

Model Description

Data Source

The estimation sample for the revised version (B) of the model consisted of 1356 men aged 45-59 in 1966 who were respondents to the 1966 through 1978 waves of the NLS. The original model (version A) was developed on a sample of 1935 male respondents to the 1966-76 NLS.

Model Specification

For this model, retirement was defined as stopping work full-time. The probability of retirement was estimated using a regression-type hazard

[2]A hazard model assumes that there is a time-to-failure (stopping work) or hazard of retirement that is a partial function of time. The hazard principle is assumed to work in a fashion analogous to certain physical objects, such as light bulbs, which have limited lives. The time it takes for a light bulb to fail can be probabilistically specified based on variation in failure rates for all light bulbs. The distribution of failure rates across all light bulbs can be called a hazard function, which is the mathematical function used to estimate the probability of failure for an individual light bulb. By viewing retirement as a similar process, the time to failure (discontinuation of work life) for an individual or group can be estimated using the hazard function. These probabilities of retirement can then be modeled as a function of a set of predictors as is done with other model types.

model. The hazard model allows the risk of retiring to vary as a function of time. (Refer to the discussion in chapter 4 of the main volume of this report for a more complete description of hazard models.)

Factors which might affect the probability of retiring that were included in the model were health, education, marital status, number of dependents, wealth, permanent income of husband and of wife, expected pension benefits, expected social security benefits, the interaction of those benefits with age variables representing eligibility status for full or reduced benefits, and time.

A second estimation of the model on a sample of 500 men was done using self reports of retirement status as the outcome variable with comparable results.

Simulation Method

The model was used to examine the effects of eliminating the availability of social security benefits to those under the age of 65 by using the full sample of respondents, aged 62, 63 and 64, who were not retired in 1975, as input values and applying the regression equation to obtain baseline estimates of the probability of retirement for these men. A second application of the regression equation was then made under the assumption of no social security benefits for these men. Changes in the resulting probabilities of retirement were then compared to the baseline probability estimates to determine the effects of the proposed change.

A similar simulation was run on men aged 58-59 in 1966 and not retired in 1978 to study the effects of increasing the normal age of retirement to 68 with eligibility for early retirement at age 65. For this simulation, benefits prior to age 65 were set at zero and the model's parameters for benefits at ages 62-64 were used to simulate early benefits at ages 65-67.

Model Review

Model documentation included likelihood values for the various model versions and standard errors for the estimated effects of each predictor. These statistics are indicators of the model's validity, or ability to predict the retirement decision. The model developers reported obtaining comparable results on a variety of alternative specifications of the model, including an alternative definition of retirement, and use of differing estimation samples. They concluded that the major results from the model are robust to changes in the model specification.

This model was used to simulate the effects of changing the eligibility ages for early and normal retirement social security benefits from 62 and 65 to 65 and 68 respectively. This particular policy change experiment pre-dated the 1983 legislated change in normal retirement age and thus the results are of less current interest than they otherwise might be. Rather, the simulations can be viewed as examples of the kinds of policy experiments that could be done with a hazard-type model.

References

DIAMOND, P. A., and J. A. Hausman. "The Retirement and Unemployment Behavior of Older Men." In H. J. Aaron and G. Burtless (eds.), Retirement and Economic Behavior. Washington, D.C.: The Brookings Institution, 1984.

———. "Individual Retirement and Savings Behavior." Journal of Public Economics, 23:1/2 (1984), 81-114.

Diamond-Hausman Probit Model

Background and Use

The Diamond-Hausman probit model was developed in 1984 to study the effects of social security and other factors, on the outcome of older workers' unemployment spells after being permanently discharged from their jobs—whether they retire or find a new job. The model has not been used for policy experimentation or forecasting and there are no current plans for such use. Further information is available from its developers: Peter A. Diamond and Jerry A. Hausman, Department of Economics, Massachusetts Institute of Technology, E52-271A, Cambridge, MA 02139.

Model Description

Data Source

This model was estimated on a sample of 414 men aged 45-71 who had been fired from their jobs. The men were respondents to the 1966-1978 NLS.

Model Specification	In this model, retirement was defined as permanent withdrawal from the labor force (as opposed to unemployment which is being out of work but in the labor force). The model developer did not specify how retirement and unemployment were operationalized. The effects of various predictors on the probability of retiring after being fired from the main job were modeled with probit estimation procedures. Economic predictors included early and normal retirement age social security benefits, full and reduced private pension benefits, wealth and the permanent incomes of husband and wife. Non-economic predictors included age, marital status, education, dependents, time and health status.
Model Review	The model documentation included the likelihood value associated with the model and standard errors for each of the predictors. These statistics are indicators of the model's ability to explain the outcome variable. Model results were also compared to results from a competing risks model (described in the next entry) which used the same set of predictors and the same sample. Comparable results were obtained. The model has not been used for policy experiments or forecasting. It has limited generalizability since it focuses solely on workers who were fired from their jobs. However, for this class of workers, the model provides some information on the effects of unemployment on retirement.
Reference	DIAMOND, P. A., and J. A. Hausman. "The Retirement and Unemployment Behavior of Older Men." In H. J. Aaron and G. Burtless (eds.), Retirement and Economic Behavior. Washington, D.C.: The Brookings Institution, 1984.

Diamond-Hausman Competing Risks Model

Background and Use	The Diamond-Hausman competing risks model was developed in 1984 to study the effects of social security, health and other factors on the length of unemployment spells that eventually lead to retirement or reemployment. The model has not been used for public policy experimentation or forecasting and there are no plans for such use. Further information is available from its developers: Peter A. Diamond and Jerry A.

Hausman, Department of Economics, Massachusetts Institute of Technology, E52-271A, Cambridge, MA 02139.

Model Description

Data Source

The model was estimated on a sample of 414 men aged 45-71 who had been fired from their jobs. The men were respondents to the 1966-1978 NLS.

Model Specification

Retirement was defined as permanent withdrawal from the labor force. The model developer did not specify how retirement status and unemployment status were differentiated. Two outcome variables were modeled—the time (the log of months) from job discharge until retirement and the time from job discharge until re-employment. The outcomes were modeled simultaneously using a competing risks model, a generalization of the hazard model of retirement for more than one event. The model yields two equations, one each for the two outcome variables.

Economic variables included in the model were early and normal retirement age, social security and private pension benefits, wealth, and permanent incomes of husband and wife. Non-economic predictors included age, marital status, education, dependents, time, and heath status.

Model Review

The model documentation included the likelihood value associated with the model and standard errors for each of the predictors. These statistics are indicators of the model's validity. Model results were also compared to results from a simple probit model of the decision to retire (described in the previous entry) for the same sample of individuals. Comparable results were obtained in both models.

The model has not been used for policy experimentation or forecasting. It has limited generalizability since it focuses exclusively on fired workers. However, for this class of workers, the model provides some information on the effects of health, social security and other variables on the consequence and duration of unemployment spells among older workers.

Reference

DIAMOND, P. A., and J. A. Hausman. "The Retirement and Unemployment Behavior of Older Men." In H. J. Aaron and G. Burtless (eds.), Retirement and Economic Behavior. Washington, D.C.: The Brookings Institution, 1984.

Fields-Mitchell Model

Background and Use

The Fields-Mitchell model was developed in 1983 and revised in 1984 to assess the effects of retirement age of five proposals to restructure the Social Security system. These reforms include increasing the normal retirement age, changing the early retirement reduction factor, increasing the late retirement credit, increasing the gain for retiring later, raising benefits in steps, and delaying the cost of living adjustment. Results from the model were used to support 1983 testimony before the House Committee on Ways and Means on reform proposals which led to the enactment of the 1983 Social Security Act amendments. Further information is available from its developers: Gary S. Fields and Olivia S. Mitchell, Department of Labor Economics, 168 Ives Hall, School of Industrial and Labor Relations, Cornell University, Ithaca, NY 14853.

Model Description

Data Source

The estimation sample for this model consisted of 1,024 white married men aged 59-61 in 1969 who were respondents to the 1969-1979 RHS. All were noninstitutionalized private sector wage and salary workers.

Model Specification

For this model, retirement was defined as leaving the job held in 1969. The outcome variable was the age at which a worker left his 1969 job. Details on how age of retirement was defined for those still working in 1979, if any, were not provided. The model was estimated using an ordered logit technique, described more fully in the Mitchell-Fields entry.

Predictors included, for each age, the present value of the lifetime income stream (from age 60 onward) derived from earnings, social security and private pensions, and available years of retirement. Private

pension income was estimated for age 65 retirement using industry-level benefits and for other ages using quasi-actuarial adjustment factors.

Simulation Method

Individual data on respondents' earnings, social security benefits and private pension benefits were updated to expected 1982 values. The model was then used to estimate baseline probabilities of retiring at each age, and experimental probabilities given the budget sets implied by various social security reforms.

Model Review

Model validity statistics were provided in the documentation (1984b). Parameter estimates were significantly nonzero and the ordered logit model was statistically reasonable.

This model has been used to assess a variety of social security reform proposals. It is based on the model developed by Mitchell and Fields. Experimental results from the model are speculative given that they are based on construction of a pseudo-cohort and that pension benefits (a major component of the lifetime income stream) were fully imputed for all workers.

References

FIELDS, G. S., and O. S. Mitchell. Restructuring Social Security: How Will Retirement Ages Respond? Washington, D.C.: National Commission for Employment Policy, 1983.

———. The Effects of Social Security Reforms on Retirement Ages and Retirement Incomes. Cambridge, Mass.: National Bureau of Economic Research, 1984a.

———. Retirement, Pensions and Social Security. Cambridge, Mass.: MIT Press, 1984b.

Gohmann-Clark Benefit Acceptance Model

Background and Use

The Gohmann-Clark model of benefit acceptance was developed in 1984 to examine the effects of the amount of social security benefits and other financial factors on the decision to accept social security benefits, and to compare these effects to similar effects on the decision to withdraw from the labor force after benefit acceptance. (A separate model, the Gohmann-Clark model of labor force participation, was developed to explain the latter decision, and is described in the next appendix entry.) The model has not been used for forecasting or public policy experimentation. Further information is available from its developers: Stephan F. Gohmann and Robert L. Clark, Department of Economics and Business, North Carolina State University, P.O. Box 5368, Raleigh, NC 27650.

Model Description

Data Source

The estimation sample for this model included 588 single non-self-employed males aged 58-63 in 1969 who were respondents to the RHS. All had accepted social security benefits in the period 1968-1975 and had not withdrawn from the labor force prior to benefit acceptance.

Model Specification

For this model, retirement was defined as the age at which social security benefits were accepted. A sequential logit procedure was used to estimate conditional probabilities of retiring at each of three age categories: 62, 63-64, and 65—given that retirement did not occur at earlier ages. The model yields three equations, one for each of the three retirement age groups.

Non-financial predictors of the benefit acceptance decision included race, education, birth year, existing or recently acquired health limitations, job tenure and presence of mandatory retirement rules on the present job. Financial predictors included wealth, earnings after benefit acceptance, the change in earnings that occurred as a result of accepting

benefits, eligibility for a private pension, amount of social security benefits and whether post-benefit acceptance earnings partially or totally reduced benefits due to the social security earnings test.

Model Review

Likelihood values, significance levels of individual predictors, and two additional measures of model performance (McFadden's R^2 and Efrom's R^2) were reported in the model documentation for each of the three equations. The explanatory power of the model was best for those accepting benefits at age 65.

Differences among the equations were accepted by the developers as theoretically plausible.

The model has not been used for policy experimentation or forecasting. Rather, it can be viewed in conjunction with the Gohman-Clark model of labor force participation as a demonstration of how the social security program differentially affects the benefit acceptance and labor force participation decisions. The model has limited generalizability since it was estimated solely on a sample of single males.

Reference

GOHMANN, S. F., and R. L. Clark. Social Security Benefit Acceptance and the Retirement Decision. Raleigh, N.C.: North Carolina State University, Department of Economics and Business, 1984.

Gohmann-Clark Labor Force Participation Model

Background and Use

The Gohmann-Clark model of labor force participation was developed in 1984 to examine the effects of the amount of social security benefits and other financial factors on the decision to withdraw from the labor force after social security benefits have been accepted, and to compare these effects to similar effects on the initial decision to accept benefits. (A separate model, the Gohmann-Clark model of benefit acceptance, was developed to explain this initial decision and is described in the preceding entry.) The model has not been used for forecasting or public

policy experimentation. Further information is available from its developers: Stephan F. Gohmann and Robert L. Clark, Department of Economics and Business, North Carolina State University, P.O. Box 5368, Raleigh, NC 27650.

Model Description

Data Source

The estimation sample for this model included 588 single non-self-employed males aged 58-63 in 1969 who were respondents to the RHS. All individuals included in the sample had accepted social security benefits at some time during the period 1968-1975 and had not withdrawn from the labor force prior to benefit acceptance. The 1969-1975 RHS observations were used to estimate the lag between benefit acceptance and labor force withdrawal.

Model Specification

For this model, retirement was defined as labor force withdrawal. The outcome variable estimated by the model was years after social security benefit acceptance until the individual withdrew totally from the labor force. Ordinary least squares regression procedures were used to estimate years to retirement.

Non-financial factors included in the model were race, health, job tenure, and years remaining before any mandatory retirement rules come into effect.

Financial factors in the model include wealth, earnings after accepting social security benefits, whether income is subject to the social security earnings test, eligibility for a private pension, the number of years after acceptance of social security benefits before eligibility for a private pension occurs, and the amount of social security benefits.

Model Review

Standard model validity measures, including R^2 and significance tests for the model and individual predictors were included in the model documentation. The model explained a significant amount of the observed variation in years to retirement after benefit acceptance.

The model has not been used for policy experimentation or forecasting. Rather, it can be viewed in conjunction with the Gohman-Clark model of

benefit acceptance as a demonstration of how the social security program differentially affects the benefit acceptance and labor force participation decisions. The model has limited generalizability since it was estimated solely on a sample of single males.

Reference

GOHMANN, S. F., and R. L. Clark. Social Security Benefit Acceptance and the Retirement Decision. Raleigh, N.C.: North Carolina State University, Department of Economics and Business, 1984.

Gordon-Blinder Model

Background and Use

The Gordon-Blinder model was developed in the late 1970s to estimate the relative importance of health, wages, social security, private pensions and preferences in explaining retirement decisions. Further information is available from its developers: Roger H. Gordon, Department of Economics, University of Michigan, Ann Arbor, MI 48109, and Alan S. Blinder, Department of Economics, Princeton University, Princeton, NJ 08544.

The model output yields tables of the probability of retiring at a given age which can be disaggregated by occupation, education, health status and other factors. These probabilities were used to predict the decisions of those individuals whose responses were used to develop the model and they were used to assess the effects on retirement of changing particular variables—such as increasing wages or social security benefits.

Model Description

Data Source

The sample used to develop this model consisted of approximately 6,000-7,000 non-self-employed white men aged 58-63 in 1969 who were respondents to the 1969 RHS. Up to three observations—from 1969, 1971 and 1973—were taken from each person. These observations were treated as though they were independent and were pooled to form a data set of 15,981 observations which were used to estimate the model.

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Model Specification

The Gordon-Blinder model defines and measures retirement as zero hours of work. The model estimates the effects of various factors on the retirement decision by assuming that the influence of these factors is through their effects on the market wage (or wage offer) and the reservation wage (the wage below which the worker will not continue to work). The model uses maximum likelihood procedures to jointly estimate the market wage and the reservation wage and predicts retirement when the former is less than or equal to the latter.

Thirty variables were used to estimate the market wage. These variables reflect the effects of education, occupation, age, job tenure, pension coverage and health on the wage rate. Nineteen variables were used to estimate the reservation wage. These variables reflect the effects of education, occupation, age, family status, pension coverage, health, available lifetime earnings and the earnings substitution potential of social security on the reservation wage.

Model Review

The model's validity was assessed with statistical tests of the model's ability to correctly classify workers and retirees. Classification results and significance levels for the statistical tests were provided in the model documentation. A critique and response to the theoretical validity of the model's treatment of social security is available in the National Tax Journal.

This model has not been used for forecasting or policy experimentation. It is one of the earliest structural models of the retirement decision, based on life cycle theory.

References

BLINDER, A. S., R. H. Gordon, and D. E. Wise. "Reconsidering the Work Disincentive Effects of Social Security." National Tax Journal, 33:4 (1980), 431-42.

———. "Rhetoric and Reality in Social Security Analysis—A Rejoinder." National Tax Journal, 34:4 (1981), 473-8.

BURKHAUSER, R. V., and J. Turner. "Can Twenty-Five Million Americans Be Wrong?—A Response to Blinder, Gordon, and Wise." National Tax Journal, 34:4 (1981), 467-72.

GORDON, R. H., and A. S. Blinder. "Market Wages, Reservation Wages, and Retirement Decisions." Journal of Public Economics, 14:2 (1980), 277-308.

Gustafson Model

Background and Use

Gustafson's model of retirement behavior was developed in 1982 primarily to test the sensitivity of estimates of the probability of retirement to variations in empirical model specifications. The basic model was designed to be comparable to reduced-form life cycle models developed by others. Many of these models are described in other entries in this report. Further information is available from its developer: Thomas Gustafson, HCFA/OLP, Division of Medicaid and Long-Term Care, Department of Health and Human Services, Room 339-H Humphrey Building, 200 Independence Avenue, S.W., Washington, DC 20201.

The model has not been used for policy analysis or forecasting and there are no plans or recommendations from the developer for such use in the future. Rather the model is useful for helping to interpret why models of retirement with differing empirical specifications may yield results that differ.

Model Description

Over 20 specifications of the model were estimated using two estimation methods—probit and ordinary least squares regression. Generally, the two procedures yield similar results. The majority of the specifications were estimated on a sample of white married men. However, a few estimations were performed on samples of single and non-white men for comparison purposes. The basic model is described below followed by a discussion of the variations in specification that were done. For this model, we present a summary of the results of the changes in specification because they may have implications for interpreting outcomes from any of the retirement decision models described in this report.

Data Source

The primary sample used to develop model estimates (versions A-P) included 1211 white married men aged 55-69 who were neither farmers nor self-employed in their last jobs. All were respondents to the 1976 NLS. Other samples from the 1976 NLS used for some of the model estimates included 1) 101 white unmarried males (version S), 2) 362 non-

white married males (version Q) and 3) 97 non-white unmarried males (version R).

Basic Model Specification

For the baseline model (version A), retirement was defined as labor force withdrawal and was measured as no labor force participation in the week the survey was conducted. In this basic model, the effects of social security on retirement were estimated by including a measure of social security wealth. This value was constructed for each individual in the sample on the basis of their work histories. The effects of private pensions on retirement were estimated through a measure of private pension asset value (or wealth). Other financial factors included in the model were total family assets and the worker's wages. Non-financial characteristics included in the model were the worker's age, wife's age, worker's education, wife's education, the local unemployment rate, number of dependents, occupation, and a summary measure of health limitations.

Successive changes in the measurement of both the dependent variable and the factors influencing retirement were made and the model was re-estimated for each change. Results from each re-estimation were compared to those from the basic model to examine the sensitivity of the model to variations in empirical specifications.

Model Review

Validity

Four alternate definitions of retirement were used as the dependent variable: 1) leaving the main job (version F), 2) earning less income than allowed by the social security earnings test (version G), 3) receiving private pension or social security benefits (version H), and 4) working less than a half year (version I). Results indicated that the goodness of fit of the model, or its ability to explain variation in the retirement decision, and the significance of individual factors in the model varied depending on which definition of retirement was used.

Using the basic model definition of retirement, additional specifications of the model were made by independently varying the measurement of wages, private pension influences, social security influences and health specifications of the model.

In the basic model, wages and private pension assets were estimated from sample data. These wage (version B) and asset (version C) equations were re-estimated by including a correction factor for sample self-selection bias. The new equations were then entered and the complete model re-estimated. Results indicated that the inclusion of the correction factor had little effect on overall model output or performance.

Social security and private pension asset values were replaced in the basic model with measures of social security and private pension eligibilities. Results from this estimation (version E) indicated little change in the interpretation of the various factors influencing retirement and a slight improvement in model fit. (One measure of the goodness of fit of the model is the percentage of variance in retirement behavior that the model explains. The basic model explained 43 percent of the variance in labor force participation and the model using eligibility rather than asset variables explained 46 percent of the same variance.)

An additional variation of the measurement of social security effects was performed. For this estimation of the model, the constructed estimate of social security assets was replaced with a measure imputed from sample characteristics. Using the imputed measure, the overall fit of the model was slightly poorer (explained variance dropped to 40 percent) and the significance of social security as a predictor of retirement behavior was noticeably lower.

Six variations of the model were estimated by altering the treatment of health as a factor influencing retirement. The basic model used an activity limitation summary score to measure health. Four different definitions of health limitations were tested: 1) work limitations (version J), 2) self-assessment of health relative to peers (version K), 3) a functional limitation index (version N), and 4) 13 individually identified limitations (version L). In addition, the sample was partitioned into two groups—one with and one without health limitations. The basic model, excluding the health factor, was estimated on both samples and the two estimations were compared. The overall fit of the model to the two samples (version M) was about the same and there was little difference in the significance of the various factors in the two models. However, the two model specifications did differ significantly by a statistical test.

The final variation in specifications entered factors representing an interaction between health and social security assets. Two of the five definitions of health were used to construct the interaction variable—

the activity limitation summary score (version O) from the basic model and the work limitation factor (version P) used in one of the model variants described above. The interaction was a significant predictor of retirement behavior only when the latter measure of health was used.

Finally, the basic model and a few of the variants were estimated on samples of white unmarried males, non-white unmarried males and non-white married males. Statistical comparisons of the resulting models showed no differences between the two models based on samples of non-white males and no differences on the two models based on unmarried males. However, the basic model based on a sample of married white males differed from all three of estimations based on the other groups.

The model has not been used for policy experimentation or forecasting and there are no plans to revise or extend the model for such use in the future. Rather, the model is useful as a general test of the sensitivity of reduced form life cycle models to variations in model specifications.

Reference

GUSTAFSON, T. A. The Retirement Decision of Older Men: An Empirical Analysis. Ph.D. diss., Yale University, New Haven, Conn., 1982.

Gustman-Steinmeier Reduced-Form Model

Background and Use

The Gustman-Steinmeier reduced-form model of retirement behavior was developed in 1981 to examine the effects on model outcomes of varying the classification of partially retired workers. The model has not been used for policy experimentation or forecasting and there are no current plans for such use. Further information is available from its developers: Alan L. Gustman, Department of Economics, Dartmouth College, Hanover, NH 03755 and Thomas L. Steinmeier, Economics Department, Texas Tech University, Box 4470, Lubbock, TX 79409-4470.

Model Description

Data Source

The estimation sample for this model consisted of non-self-employed white males who were respondents to the 1969-1975 RHS. Exact sample sizes were not reported.

Model Specification

The model defined retirement by the self-assessed status of respondents—fully working, fully retired, partially retired in the main job, or partially retired outside the main job. The effects of various predictors on retirement status were estimated using a discrete multivariate analysis algorithm.

Predictors included age, marital status, presence of dependent children and dependent parents, usual hourly wage, wage in a partial retirement job, social security, public and private pension coverage, presence of mandatory retirement provisions on the main job, and health status.

Model Review

Neither model validity nor individual predictor validity statistics were provided in the model documentation. The results of statistical significance tests on alternative specifications of the model which included interaction terms were given.

This model was not developed for use in conducting policy experiments or forecasting and the developer does not recommend such use. Rather, the model can be viewed as providing empirical support for the specification of a structural model, developed subsequently by Gustman and Steinmeier and described in the next entry. The model also provides a test of the sensitivity of model results to changes in the classification of part-time workers.

Reference

GUSTMAN, A. L., and T. L. Steinmeier. Some Theoretical and Empirical Aspects of the Analysis of Retirement Behavior. Washington, D.C.: National Technical Information Service, 1981.

Gustman-Steinmeier Structural Model

Background and Use

The Gustman-Steinmeier structural model of retirement was developed in 1983 and revised in 1985 to provide a structural life cycle model which incorporates partial retirement as a behavior option. Further information is available from its developers: Alan L. Gustman, Department of Economics, Dartmouth College, Hanover, NH 03755 and Thomas L. Steinmeier, Economics Department, Texas Tech University, Box 4470, Lubbock, TX 79409-4470.

The model was used to simulate the overall and separate effects of the 1983 Social Security Act amendments. Simulated separate effects include: 1) increasing the normal retirement age and the age 62 penalty for early retirement, 2) increasing the delayed retirement credit, 3) adjusting the earnings test taxation of benefits, and 4) delaying COLAs by six months.

In addition, the model was used to simulate the effects on retirement age of changes in long-term economic growth (e.g., increases in labor productivity over a couple of decades), elimination of private pension income and the onset of a long-term health problem at age 55.

The model is continuing to be revised to facilitate further policy analyses and has been extended to cover additional demographic groups (black as well as white males) and those in more versus less physically demanding occupations. There are tentative plans to use the model to evaluate EEOC (Equal Employment Opportunity Commission) regulations requiring pensions to be granted on equal terms to older individuals beyond normal retirement age.

Model Description

Data Source

The estimation sample for the initial version of the model consisted of 478 white males who were respondents to the 1969-1975 RHS. A maximum of four observations on each individual was used in the estimation. The disaggregated version of the model was estimated on samples of 510 white and 281 black males in more physically demanding jobs

and on 366 white and 129 black males in less demanding jobs. The updated and disaggregated version of the model uses RHS data from 1977 and 1979, and uses up to six observations on each individual.

Model Specification

Retirement was defined by self-assessed status as working, partially retired or fully retired. A temporal work pattern sequence (four, and in later versions, six observations) was observed for each individual. Theoretically reversed sequences, such as going from a fully retired to a fully employed status were ignored. The model was estimated using maximum likelihood techniques on a CES (constant elasticity of substitution) function of consumption and leisure. The model yields estimates of the effects of hypothetical constructs, such as preference for leisure, derived from life cycle theory, on the retirement decision.

Variables included in the model were age, health and year of birth, wage offers for full and part-time work (estimated from information on the respondents' job tenure, years of experience, occupation, education, health, pension eligibility and mandatory retirement horizon) and changes in the present discounted value of both social security and private pension benefits which would occur if retirement were delayed an additional year. (Estimates of pension benefit changes were imputed from information on respondent's occupation, industry of employment, years of service and wage rate.)

Simulation Method

The model was first used to construct baseline probabilities of full or partial retirement at each age 58-68 inclusive and aggregated probabilities at ages 57 and below and 69 and above. Simulations were done by altering individual characteristics to correspond to proposed changes and applying the basic model to calculate new probability estimates.

Model Review

Validity

Overall model validity statistics were not provided but standard errors for individual predictors were. In addition, the model's estimates of the probabilities of retiring at each age were compared to observed data on the estimation sample. The model captured the basic shape of the distribution of retirement ages, although it underestimated age 63 retirement probabilities and over-estimated age 66-68 retirements.

The sensitivity of many of the model's assumptions were tested by altering the model specification, re-estimating the model and comparing results to baseline model estimates. Assumptions tested in this way included alternative views on work restrictions, alternative methods for calculating wage and pension income and changes in the operationalization of partial and full retirement status. The model showed varying degrees of sensitivity to assumptions.

Sensitivity analyses were also performed on the results of simulated reforms to the social security program. These analyses included altering the assumed inflation rate, the wage rates, pension benefits and other real quantities, and the normal retirement age for private pensions. Only the latter change produced more than marginal differences in the simulations.

Pairwise chi square tests of the equality of model parameters across all four disaggregated versions of the model were reported. Results indicated that separate models are appropriate for blacks and whites and for whites in more versus less physically demanding jobs.

Use

The model is useful for examining the short and long run effects of various policy reforms on retirement behavior. However, the results of the simulations performed by the model pertain to perceived retirement status, the modeled outcome variable. To the extent that perceived retirement status correlates with other definitions of retirement, the simulations are useful for understanding the effects of policy and other future changes on retirement. (The developers reported that they tested the sensitivity of their model to specifications of the outcome variable and that results were consistent with ones obtained when labor force participation was the modeled outcome.)

References

GUSTMAN, A. L., and T. L. Steinmeier. "Minimum Hours Constraints and Retirement Behavior." Contemporary Policy Issues, No. 3 (April 1983), 77-91.

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Hamermesh Model

Background and Use

The Hamermesh model was developed in 1982 to examine the effects of perceived mortality and other factors on retirement. The model has not been used for policy analyses or forecasting. Further information is available from its developer: Daniel S. Hamermesh, Department of Economics, Michigan State University, East Lansing, MI 48824.

Model Description

Two specifications of the model were made on samples with quite different characteristics. The specifications differ largely because of differences in the kinds of data available on the two samples. Since both specifications define retirement with respect to labor force behavior and both focus on the use of perceived rather than actual mortality estimates, the two specifications are treated here as a single model.

Data Source

The first specification of the model (version A) was done on a sample of 1978 white males aged 62-67 who were respondents to the 1973 RHS. The model was re-estimated on a sample of 1422 men aged 64-69 who were 1975 RHS respondents (version B). In both of these samples, the men were all married to the same spouse from 1969 until the survey year (1973 or 1975) and their spouse's ages were between 56 and 80 in the survey year. No self-employed, military, or public sector employees were included in the samples.

The second specification of the model was done on two samples of gifted (high IQ) males who were participants in a longitudinal study of the gifted conducted by Terman. One sample (version C) consisted of 320

men who were respondents to a 1972 survey wave and the other (version D) consisted of 228 men who responded to a 1977 survey wave. There was some overlap in individuals responding to the two surveys. All men were aged 55-70 in either 1972 or 1977, worked each year between 1956 and 1959 inclusive and had no living parents.

Model Specification

For the model specification based on the RHS sample, retirement was defined as a continuous variable—the fraction of the average work week over a two-year period spent in leisure (not working). The effects of various factors on retirement were estimated simultaneously with their effects on consumption. Only the factors included in the final equation describing retirement are described here.

Non-economic factors in the model included respondent's age, spouse's age, household size, number of children, occupation, education, health, spouse's work status, and perceived mortality. The latter variable was calculated by adjusting actuarial survival probabilities for the number of living parents of the respondent and his spouse and the average number of living parents in the entire estimation sample.

Economic factors included in the model were net wealth, social security wealth and private pension wealth. The latter two variables were constructed by adjusting the wealth estimates to account for the couple's perceived mortality, in a manner similar to that done with the perceived mortality factor described above.

For the model specification based on the sample of gifted males, retirement was defined as self-reported work status in one of three categories: 1) not working, 2) working part-time, and 3) working full-time. Two multinomial logit functions were estimated to predict the probability of being in each of the three categories as a function of several variables. One estimation was based on the 1972 survey responses, the other on the 1977 survey responses.

Non-economic factors included in the model were age, occupation, health status, number of living children, age when last living parent died, and perceived mortality. The latter variable was calculated by adjusting actuarial life expectancies for the longevity of the respondents' parents. For the estimation based on the 1977 sample, presence of mandatory retirement provisions on the job was also included as a factor.

Financial variables in the model included potential eligibility for early or regular social security retirement benefits, and average earnings between 1956 and 1959. No asset, private pension or social security benefit factors were included in the model because such information was not available on the survey respondents.

Model Review

Likelihood values for the models based on the Terman samples, weighted R^2 values for the models based on the RHS samples, and the statistic for featured predictors were provided in the model documentation. Results pertaining to perceived mortality did not replicate across the two Terman samples, and overall results were interpreted by the developer to be inconsistent with life cycle theory. Alternative model specifications did not improve replicability of results. Results did replicate in direction but not magnitude of effects for the RHS-based models.

The model has not been used for policy analysis or forecasting. Rather, it can be viewed as being in a theoretical stage of development. Its uniqueness is in the inclusion of subjective mortality in the model. However, the factor is measured only indirectly and thus far has not been empirically validated.

References

HAMERMESH, D. S. Life-cycle Effects on Consumption and Retirement. Cambridge, Mass.: National Bureau of Economic Research, 1982.

———. "Consumption During Retirement: The Missing Link in the Life Cycle." Review of Economics and Statistics, 66:1 (1984), 1-7.

Hausman-Wise Brownian Motion Model

Background and Use

The Hausman-Wise Brownian motion[3] model was developed in 1984 to examine the effects of health and social security on retirement by taking

[3]A well known example of Brownian motion is the random walk. The probability of arriving at some end point or state given the starting point of the walk can be calculated with a Brownian motion model. Interfering barriers along the walk can be specified which change the state an individual is in, temporarily or permanently. A barrier, such as a manhole, which causes a permanent state change is

full advantage of the continuous time nature of the retirement decision. It was specifically developed as an alternative to the hazard model of retirement (described in the next entry). It has not been used for policy analysis or forecasting. Further information is available from its developers: Jerry A. Hausman, Department of Economics, Massachusetts Institute of Technology, E52-271A, Cambridge, MA 02139, and David A. Wise, J.F.K. School of Government, Harvard University, 79 Boylston St., Cambridge, MA 02138.

The model is currently being revised.

Model Description

Data Source

The estimation sample for this model consisted of 2000 non-self employed males aged 58-63 in 1969 who were respondents to the 1969-1979 RHS. Observations from each survey year until the respondent retired were used in the estimation.

Model Specification

In this model, retirement was defined as working less than the required hours on the primary job. The probability of an individual retiring at a given age was modeled using the Brownian motion probability distribution function which requires an estimation of desired hours of work. These probabilities were then modeled as a function of a set of predictor variables, using maximum likelihood estimation procedures.

Four alternative specifications of the model were estimated. The specifications differed in how the effects of social security were measured and whether or not a hypothetical construct, called an absorbing barrier (refer to discussion in chapter 4 of the main volume of this report for a definition of absorbing barrier), was included as a predictor. Two of the models (one including an absorbing barrier and one not including it as a predictor) based the effect of social security on monthly benefits and the changes in benefits that would occur if retirement were delayed for one year. The other two models based the effects of social security on

called absorbing. Retirement is viewed as an analogous process with a random drift toward fewer hours of work until a barrier (some lower limit on hours of work) is reached and the individual retires. One version of the model specifies that the barrier is absorbing (the worker cannot return to the non-retired state) and one version allows freedom of movement between states. The effects of the barrier and other variables on the probabilities of retiring, based on Brownian motion, are then estimated using techniques comparable to those in other models.

social security wealth and the changes in wealth that would occur for delaying retirement an additional year.

The remaining predictors were constant in all four model specifications, and included health status, earnings, private pension eligibility, education and number of dependent children.

Model Review

The model documentation included likelihood values for each of the four model specifications and standard errors for the estimated effects of each predictor. These statistics are indicators of the model's validity, or ability to predict the retirement decision. The overall performance of the model which used social security benefits as a predictor was better than that of the model using the social security wealth variables. The models including the absorbing barrier as a predictor were approximately equivalent to the models which omitted this variable.

The model developer noted that results from the model were not entirely plausible.

This model has not been used for policy analysis or forecasting. Rather, it can be viewed as a model that is still in a development stage. The current version of the model did not yield results that were satisfactory to the model developers. The model is undergoing revision and refinement and future versions may prove more useful.

Reference

HAUSMAN, J. A., and D. A. Wise. "Social Security, Health Status, and Retirement." Massachusetts Institute of Technology, Cambridge, Mass., n.d.

Hausman-Wise Hazard Model

Background and Use

The Hausman-Wise hazard model[4] was developed in 1984 to examine the effects of health and social security on retirement by taking full advantage of the continuous time nature of the retirement decision. It was used to simulate the effects on retirement age of maintaining social

[4]See footnote 2 for definition of hazard model.

security benefits at 1969 levels and allowing benefit payments to begin at age 65 instead of 62. Further information is available from its developers: Jerry A. Hausman, Department of Economics, Massachusetts Institute of Technology, E52-271A, Cambridge, MA 02139 and David A. Wise, J.F.K. School of Government, Harvard University, 79 Boylston Street, Cambridge, MA 02138.

Model Description

Data Source

The estimation sample for this model consisted of 2000 non-self employed males aged 58-63 in 1969 who were respondents to the 1969-1979 RHS. Observations from each survey year until the respondent retired were used in the estimation.

Model Specification

In this model, retirement was defined by self-assessed status as either fully or partially retired. The conditional probability of retiring at a specified age given that the person has not retired prior to that age was modeled using a mathematical time-to-failure or hazard probability distribution function. These probabilities were then modeled as a function of individual attributes using hazard-type regression procedures.

Four alternative specifications of the model were estimated. The specifications differed in how the effects of social security were measured and whether or not liquid assets were included as a predictor. Two of the models (one including liquid assets and one not including them as a predictor) based the effects of social security on monthly benefits and the changes in benefits that would occur if retirement were delayed for one year. The other two models based the effects of delaying retirement an additional year.

The remaining predictors were constant in all four model specifications and included health status, earnings, private pension eligibility, age, education and number of dependent children.

Simulation Method

Simulations of social security policy changes were done by calculating the average probability of being retired by ages 62, 64 and 66 for the subsample of people who were aged 60 and not retired in 1969 to form a baseline estimate of retirement behavior.

For the simulation of retirement patterns if past benefit levels had been maintained at the 1969 level, the observed benefit and wealth values were replaced with what they would have been under the proposed change and the model was then applied to these alternative values to calculate the probabilities of retiring by ages 62, 64 and 66. Differences between the baseline probabilities and the simulated probabilities reflect the estimated effects of the actual program changes that occurred after 1969.

For the simulation of retirement patterns if payments were to begin at age 65 instead of 62, the benefit amounts that were actually available to the simulation sample at ages 62 through 65 were used to reflect what benefits would be available at ages 65 through 68. Benefit payments and social security wealth for persons under age 65 were set equal to zero. The model was then applied to these new values to calculate changes in the probabilities of retiring at ages 62, 64 and 66.

Model Review

Validity

This model was used to backcast the effects of social security benefit increases between 1969 and 1975 on retirement using the simulation method described above. The model predicted a labor force participation rate decline of 3 percent by age 64 in 1973 and 5 percent by age 66 in 1975. The predictions were compared to independently developed aggregate trend rates showing a 9 percent decline from 1969-1973 for men aged 60-64 and a 13.7 percent decline from 1969-1975. For men over 65, the declines for the two time intervals were 14.5 percent and 20 percent, respectively. This information could have been used as part of the model validation although the developers did not use it in that way.

The model documentation included likelihood values for each of the four model specifications and standard errors for the estimated effects of each predictor. These statistics are indicators of the model's validity, or ability to predict the retirement decision. Comparable results were obtained in all four specifications of the model, although the overall performance of the models which used social security wealth as a predictor was better than that of the models using social security benefits.

The model developer was satisfied that the model results were theoretically plausible.

Use	Although the model was used to simulate alternative social security benefit and eligibility policies, the results of the simulations pertain to perceived retirement status, the modeled outcome variable. To the extent that perceived retirement status is correlated with other definitions of retirement, the simulation results are useful for understanding the effects of iost-1969 benefit increases and potential effects of raising the normal retirement age. The model would be more directly useful if labor force participation or benefit acceptance were the outcome variable.
Reference	HAUSMAN, J. A., and D. A. Wise. "Social Security, Health Status, and Retirement." Massachusetts Institute of Technology, Cambridge, Mass., n.d.

Henretta-O'Rand Model

Background and Use	The Henretta-O'Rand model was developed in 1979 and revised in 1980 to examine the effects of personal, spouse and family characteristics on the retirement decisions of married women. The model has not been used for policy experiments or forecasting. Further information is available from its developers: John C. Henretta, Department of Sociology, University of Florida, Gainesville, FL 32611 and Angela M. O'Rand, Department of Sociology, 265 Soc-Psych, Duke University, Durham, NC 27706.

Model Description

Data Source	The Henretta-O'Rand model was estimated for four samples of married women whose spouses were respondents to the 1969, 1971, and 1973 RHS. All spouses were aged 58-63 in 1969. Although women's ages were correlated with those of their spouses, there were no age constraints on the samples of women. The four samples were 1) 1424 women under the age of 58 who were working in 1969, 2) 1218 women from the first group who were also working in 1971, 3) 761 women over the age of 58 who were working in 1969, and 4) 545 women from the third group who were also working in 1971.

Model Specification

Retirement was defined as withdrawal from the labor force after 1969 without re-entry prior to 1973. The effects of personal, spouse and family characteristics on the retirement decision were estimated using logit analysis procedures.

Personal characteristics included age, quarters of social security coverage, and hourly wage in 1969. Spouse characteristics included age, health, earnings in 1968 and labor force status in 1969. Family and retirement income measures included presence of dependents, spouses' social security benefits at age 65 and private pension coverage of self and of spouse. The model was estimated for women under 58 (version A) and over 58 (version B).

Model Review

Summaries of tests of the significance of individual model predictors were provided in the model documentation. No information on overall model validity was provided.

This model has not been used for policy experimentation or forecasting. It is unique in being one of few models of the retirement decision among married women. Some caution should be used in generalizing the results to a larger population, however, because the sample of married women was not selected to be random or representative.

Reference

HENRETTA, J. C., and A. M. O'Rand. "Labor-Force Participation of Older Married Women." Social Security Bulletin, 43:8 (1980), 40-6.

Honig-Hanoch Model

Background and Use

The Honig-Hanoch model was developed in 1983 to examine the effects of factors associated with retirement on the labor market behavior of older workers. The model consists of separate equations for a variety of measures of labor force participation. Further information is available from its developers: Marjorie Honig and Giora Hanoch, Department of Economics, Hunter College, 695 Park Avenue, New York, NY 10021.

This model has not been used for public policy analysis or forecasting and there are no current plans for such use.

Model Description

Data Source

The sample of workers used to estimate the model were married white males and unmarried white females aged 58-63 who were respondents to the 1969, 1971, 1973, and 1975 RHS. Observations from these four survey years were pooled and treated as though they were responses from entirely unique individuals. For these model estimations, there were 12,520 observations from males and 5,436 observations from females. The number of unique individuals represented by these observations was not reported. By pooling observations in this manner, the spanned age range of workers for the estimation was 58-69. Equations were estimated separately for males and females.

Several additional specifications were estimated separately on samples of 3,550 males and 1,270 females aged 62-67 who were respondents to the 1973 RHS and had previous social security covered earnings.

Model Specification

This model uses a set of worker characteristics to explain various aspects of labor force participation and differing definitions of retirement.

The large sample of pooled observations (version A, males; version B, females) was used for estimations of the decision to withdraw completely from the labor force, the number of annual hours of work and the number of annual weeks of work. The estimations were based on both probit and ordinary least squares regression procedures with similar results from the two procedures.

The smaller samples of men and women were used separately to estimate three specifications of partial retirement. The first specification (version C, males; version F, females) represented partial retirement as a two-stage decision process. The worker must decide whether or not to work and, for those who decide to work, whether the effort should be full-time or part-time. Maximum likelihood techniques were used to model the first decision on the entire sample and the second decision only on the subsample of workers who provided some work effort.

The second specification (version D, males; version G, females) also represented partial retirement as a two-stage decision process. The worker must decide first whether or not to reduce work effort (accept social

security benefits) and, for those who decide to reduce work effort, whether the reduction should be partial or complete. These two decisions were modeled in the same manner as described above for the first specification of partial retirement.

The third specification (version E, males; version H, females) represented partial retirement (or partial employment) as a decision option that is independent of full employment or complete retirement decisions. That is, in any year, a worker may choose any of three work states. Maximum likelihood methods were used to estimate the single equation implied by this specification—the choice of partial retirement over full or zero labor force participation.

Outcomes from the model varied considerably depending on the particular specification examined and whether or not the estimate was done for women or men.

The set of economic explanatory factors used in the estimations was fairly constant across all specifications of the dependent variable. These factors included family income, private pension coverage, expected social security benefit eligibility, social security primary insurance amount for the current year, years of social security covered earnings, years elapsed since first social security covered earnings, and presence of an interrupted sequence in covered earnings. Total social security earnings was included in the partial retirement equations.

Non-economic factors included in all equations were time, cohort, and age trends, health status, education and total years of work experience. Some of the equations included the effects of several additional variables. These variables included prior self-employment status, employment status of spouse, disability status, work experience on the longest job, industry of employment, area of residence (rural/urban), presence of mandatory retirement rules on the present job and market wage. Not all of these variables appeared in all equations.

Model Review

Model results were documented in three separate papers—one for the large pooled sample estimations of labor force participation and one each for the male and female partial retirement estimations. For the first estimations, only the results of the ordinary least squares regression estimations of labor force participation were reported. Model validity information was provided as were statistics on the effects of each predictor. We question the interpretation of the statistics, given

that multiple observations from individual respondents were used to form the estimation sample, and this may have violated the assumptions required for significance testing.

For other estimations, likelihood values and predictor statistics were reported for all equations.

This model has not been used for forecasting or policy experimentation and the developers do not recommend such use. Rather, it can be viewed as providing empirical support for including partial retirement as a decision option for workers in future models, and for qualitative evidence of the importance of factors such as social security and health on the retirement decision. It is one of few models which examines the retirement behavior of women.

References

HANOCH, G., and M. Honig. "Retirement, Wages, and Labor Supply of the Elderly." Journal of Labor Economics, 1:2 (1983), 131-51.

HONIG, M. "Partial Retirement in the Labor Market Behavior of Older Women." Hunter College, New York, N.Y., 1983.

———, and G. Hanoch. "A General Model of Labor Market Behavior of Older Persons." Social Security Bulletin, 43:4 (1980), 29-39.

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Hurd-Boskin Model

Background and Use

The Hurd-Boskin model of labor force participation was developed in 1981 to assess the relationship between social security benefits and retirement. It was used to estimate the effects of 1972 social security benefit increases on the changes in labor force participation rates that occurred between 1968 and 1973. It was also used to estimate the potential impact on long-run OASI cost estimates of using a behavioral response model in lieu of the typical retirement assumptions used by SSA (see entry in Appendix I). Further information is available from its developer: Michael D. Hurd, Department of Economics, State University of

New York, Stony Brook, NY 11974, and Michael J. Boskin, Department of Economics, Stanford University, Stanford, CA 94305.

The developers have presented model results in testimony before various Congressional committees and to the National Commission on Social Security Reform during its 1982 deliberations, preceding the enactment of the 1983 Social Security Act amendments.

Model Description

Data Source

The estimation sample for this model consisted of white married male respondents to the 1969-1973 RHS who were private wage workers in 1968 or 1969, had a calculable 1968-69 wage rate, had a non-working spouse, and were not on welfare. In addition, all individuals in the sample had wage rates between $1 and $35 and net worth between $5,000 and $1,000,000.

The exact number of unique individuals included in the modeling specifications was not reported by the developer. However, the number of observations available for each of the ages 59 through 65 was reported (some of the same individuals were observed at more than one age). Numbers ranged from a low of 272 men aged 65 to a high of 873 men aged 61.

Model Specification

For this model, retirement was defined as withdrawal from the labor force. The model consists of seven equations, one each for retirement status at ages 59 through 65 (versions A-G) inclusive. The equations were estimated independently using conditional logistic probability methods.

Predictors of retirement status included year of birth, health, wife's age, presence of age 65 mandatory retirement provisions on the present job, wage rate, net wealth, and social security wealth.

Re-estimations of all seven equations were performed to include factors allowing private wealth and social security wealth to interact in their effects on retirement, and factors allowing private wealth and wages to interact in their effects on retirement.

Model Review

This model was used to estimate the effects of 1969 and 1972 social security benefit increases on retirement. First 1969 observed frequencies of retiring were used to develop a baseline of conditional retirement probabilities by age. Second, the developers estimated that the 1969 and 1972 social security benefit changes resulted in a 52 percent increase in individual worker social security wealth. This figure was used to estimate the median increase in social security wealth in their sample. Results from the model were then applied to the baseline conditional probabilities to determine the effects of the median increase in social security wealth.

The model predicted an 8.4 percent decline from 1968 to 1973 in labor force participation as a consequence of the 1969 to 1972 benefit increases. Independently published figures on aggregate labor force participation trends were used to calculate the actual decline (8.2 percent) for comparison. This information could have been used as part of the model validation although the developers did not use it in that way.

Standard errors for individual predictors of retirement status were included in the model documentation. No summary measures of the model's overall validity were provided. Several general tests of the statistical significance of social security's effects on retirement were performed with consistent positive results. The developer reported that alternative specifications of the model were estimated, yielding comparable patterns for the effects of social security on retirement. Estimations of 1968-1973 labor force participation declines based on the model were very close to observed rates of decline.

This model was used initially for back-casting—predicting past behavioral responses to policy changes. The developer's focus was primarily on assessing the effects of social security on retirement, with model results being only one of many indicators of those effects. This deemphasis of the model's precise specification is reflected in the absence of model validity information.

The model was subsequently used as a submodel in an OASI cost estimate model developed by Boskin, Avrin, and Cone (1983). In that model, it replaced actuarial retirement assumptions.

References

BOSKIN, M. J., M. Avrin, and K. Cone. "Modeling Alternative Solutions to the Long-Run Social Security Funding Problem." In M. Feldstein (ed.),

Behavioral Simulation Methods in Tax Policy Analysis. Chicago: University of Chicago Press, 1983.

HURD, M. D., and M. J. Boskin. The Effect of Social Security on Retirement in the Early 1970's. Cambridge, Mass.: National Bureau of Economic Research, 1981.

Kutner Model

Background and Use

The Kutner model was developed in 1984 to provide information on retirement decisionmaking of public employees that belong to state and local government defined benefit pension plans. Only one such plan was used to develop the model. A second purpose for developing the model was to examine specifically the factors which affect retirement among educators for pension administrators and education planners who may wish to change the retirement incentive structure of pension plans. Further information is available from its developer: Stephen Kutner, School of Management, Boston University, Boston, MA 02215.

The model was used to simulate the effects on retirement age of changes in financial variables, including pension wealth, post-retirement earnings, spouse earnings, net worth and eligibility for either social security or private pension income.

Model Description

Data Source

The estimation sample for this model consisted of 1499 members of the California State Teachers Retirement System (STRS) who responded to a mail survey conducted in June 1980. Survey data was matched to the 1979 STRS actuarial valuation file. All respondents were currently or formerly employed in k-12 public school districts and were aged 55-63 in 1978. Respondents with five years of credited service in STRS were eligible for early retirement benefits with an actuarial reduction in pension income or normal retirement benefits at age 60.

Model Specification

Retirement was defined as accepting an STRS pension. The outcome variable estimated by the model was the age at which retirement occurred

(version A). For 881 respondents who were still working in 1978, retirement age was measured as present age as of the survey date. A tobit estimation procedure, designed to estimate relationships for such a censored dependent variable, was used to develop the model and correct for the measurement error in age of retirement. A second equation (version B) estimated post-retirement labor force participation.

Financial factors that were included in the model were the present value of pension benefits from STRS, eligibility for a private pension, eligibility for social security benefits, net worth, imputed post-pension acceptance earnings and earnings of spouse.

Non-financial factors included in the model were health, sex, race, marital status, and number of dependents.

Simulation Method

The exact method used to simulate the effects of alternative pension policies on the age of retirement was not described in the model documentation. The developer informed us that the simulations were performed by applying the estimated model to the entire sample to obtain baseline predictions which were compared to predictions obtained by changing predictor values to correspond with proposed policy changes.

Model Review

The model documentation provides the likelihood value associated with the model and standard errors for each of the predictors. These statistics are indicators of the model's validity.

This model has limited generalizability as it focused on a single pension plan and a restricted occupational and residential group, California educators. The simulations based on the model are useful for their stated purpose—to provide information to pension administrators and education planners concerning the effects of pension policy changes on retirement age.

Reference

KUTNER, S. I. The Effect of Pension Wealth on the Age of Retirement. Stanford, Calif.: Stanford University, Institute for Research on Educational Finance and Governance, 1984.

Mitchell-Fields Model

Background and Use

The Mitchell-Fields model was developed in 1983 to examine the role of economic factors in determining retirement behavior among workers in ten defined benefit private pension plans. It was used to estimate the effects on retirement of changes in benefit levels. It has not been used for other experimentation or for forecasting, although a similar model discussed earlier, that of Fields-Mitchell, has been. Further information is available from its developer: Olivia S. Mitchell and Gary S. Fields, Department of Labor Economics, 168 Ives Hall School of Industrial and Labor Relations, Cornell University, Ithaca, NY 14853.

Model Description

Data Source

The data source for this model is the 1978 DOL Benefit Amounts Survey. Pension plan beneficiary data was matched individually with earnings histories from SSA data files. The sample of workers included 8,733 men born in 1909 or 1910 who were participants in one of 10 defined benefit private pension plans and had retired between the ages of 60 and 69. These plans covered blue collar, manufacturing, craft and trade workers.

Model Specification

Two sets of estimations were performed. For the first, age of retirement was measured linearly and estimated with linear regression methods as a function of base wealth (the present value gression methods as a function of base wealth (the present value of income available at the earliest possible retirement age) and the gain in that wealth that would be obtained by working longer and postponing retirement. This model was estimated on the pooled sample and on ten sub-samples, disaggregated on the basis of the pension plan in which they participated.

The second set of estimations modeled retirement age as an ordered discrete choice among possible ages. Estimations were done using both multinomial logit and ordered logit procedures. The latter procedure allows the probability of retiring at each age to depend on the attractiveness of the next closest retirement ages. These models assume that the age of retirement is selected based on an age-60 analysis of the attractiveness of alternative retirement ages. Predictors of retirement age included, for

each age, the present value of the lifetime income stream (from age 60 onward) derived from earnings, social security and private pensions, and available years of retirement. Ten equations were estimated, one for each pension plan.

Model Review

Model validity statistics and significance tests for each predictor were included in the documentation for all estimations.

For the first set of estimations, the significance and direction of effects were comparable across all sample replications. The effect sizes varied across plans.

For the second set of estimations, results from the two procedures—multinomial and ordered logit techniques—were not equivalent. The developers concluded on the basis of test statistics that the assumptions underlying the multinomial procedure were violated, and therefore base their conclusions on results from the ordered logit analysis. The ordered logit analysis produced comparable results for all ten replications with the relative importance of the two predictors varying across plans.

The model was used to predict the effects on retirement age of changes in social security or private pension benefit amounts.We question the generalizability of results given that the estimation samples were not selected to be random or nationally representative. The developers are continuing to revise and extend the model for future use.

References

FIELDS, G. S., and O. S. Mitchell. "Pensions and the Age of Retirement." Cornell University, Ithaca, N.Y., 1983.

——. "Economic Determinants of the Optimal Retirement Age: An Empirical Investigation." Journal of Human Resources, 19:2 (1984), 245-62.

MITCHELL, O. S., and G. S. Fields. The Economics of Retirement Behavior. Cambridge, Mass.: National Bureau of Economic Research, 1983.

——. Retirement, Pensions and Social Security. Cambridge, Mass.: MIT Press, 1984.

O'Rand-Henretta Model

Background and Use

The O'Rand-Henretta model was developed in 1982 to assess the effects of early family and work patterns and pensions on the timing of retirement (early versus late) among unmarried women. The model has not been used for public policy analysis or forecasting and there are no plans for such use in the future. Further information is available from its developer: Angela M. O'Rand, Department of Sociology, 265 Soc-Psych, Duke University, Durham, NC 27706 and John C. Henretta, Department of Sociology, University of Florida, Gainesville, FL 32611.

Model Description

Data Source

The estimation sample for the model consisted of 1399 female respondents to the 1969, 1971 and 1973 RHS. These women were single and aged 58-63 in 1969. Only women with some earnings in each year 1964-68 were included in the sample.

Model Specification

For this model, retirement was defined as permanent withdrawal from the labor force. The dependent variable was the age at which retirement appeared to occur. This age was used to categorize women into one of four groups. 1) women who retired prior to age 62, 2) women who retired between the ages of 62 and 64, 3) women who retired at age 65, and 4) women who were still working in 1973. Two estimations of the model were made. For the first estimation, women who had retired early (prior to age 62) were contrasted with all others. For the second, early retirees were removed from the sample and women who had retired between the ages of 62 and 64 were contrasted with those retiring at age 65 or over and those still working in 1973 (aged 62-67).

A multivariate logistic regression technique was used to estimate the effects of various factors on the decision to retire early (prior to age 62 or between the ages of 62 and 64). Background characteristics included in the model were race, education, age at first job (before or after age 35), parental status, marital status, socioeconomic status (based on occupation), industry of last job, and health status. Economic factors included in the model were private pension coverage, assets, and a single pension to earnings replacement ratio. Both social security and other

pension income were used to calculate replacement ratios which were based on average annual earnings from 1964-68.

Model Review

Model chi square values, and standard errors and significance tests for each predictor were provided in the model documentation for each equation. Results from the model were plausible.

This model has not been used for forecasting or policy experimentation. Rather, it can be viewed as an exploratory model of factors that influence women's retirement. It has limited generalizability in that it focuses solely on unmarried women who were approaching retirement age in the late 1960s and early 1970s. Recent and expected future changes in women's work patterns, and differences in the work patterns of single and married women are not captured in the model. We question the usefulness of results from the second estimation since the sample of nonretirees included women aged 62-64 who could potentially become early retirees.

Reference

O'RAND, A. M., and J. C. Henretta. "Delayed Career Entry, Industrial Pension Structure, and Early Retirement in a Cohort of Unmarried Women." American Sociological Review, 47 (1982), 365-73.

Pellechio Model

Background and Use

The Pellechio labor force participation and labor supply models were developed in 1978 to examine the effect of social security on the retirement decision. The labor supply model was used to predict the effects of alternative social security earnings test policies on the retirement decisions of men aged 65-70. Alternative policies included increasing the exempt amount to $5,000, $7,000 and $10,000, decreasing the tax rate from 50 to 25 percent, and eliminating the earnings test. Further information may be available from its developer: Anthony Pellechio,[5] Price Waterhouse, 1801 K Street, N.W., Washington, DC 20006.

[5]This developer did not respond to our request for review of the accuracy of our model description. Thus, some inadvertent errors may remain in this entry.

Model Description

Data Source

The labor force withdrawal model was estimated for three samples of married men who were respondents to the March 1973 CPS and whose CPS responses were matched with IRS and SSA records. The data base containing these records is called the CPS-IRS-SSA Exact Match File. The three samples included 1) 571 men aged 60-61 (version A), 2) 706 men aged 62-64 (version B), and 3) 1173 men aged 65-70 (version C). All men in the sample were insured by the OASDI program, were not covered Railroad Retirement and were not federal or state government employees.

The labor supply model was estimated on a subset of men used in version C of the labor force withdrawal model. These men were all eligible for OASDI benefits and worked some weeks in 1972. None were receiving welfare, unemployment or disability payments.

Model Specification

For the labor force withdrawal model, retirement was defined as withdrawal from the labor force and was assessed as stopping work prior to reaching one's birthday in 1972. Probit analysis procedures were used to estimate the effects of social security and other characteristics on the retirement decision.

For the labor supply model, two outcomes were estimated: earning above the exempt amount in the earnings test and annual hours of work. Estimations in this model were based on probit procedures for the former outcome and constrained and unconstrained ordinary least squares regressions for the latter.

Social security's impact was measured by calculating social security wealth—the present value of expected lifetime social security benefits. A discount rate of three percent was used to calculate the present value of future benefits. No information on private pension benefits or eligibility were included in the model. Other characteristics included in the model were capital or asset income, education, residence, race, age and the age, education and wages of the respondent's spouse.

In addition, the number of hours required to earn the exempt amount was included as a predictor in the earnings outcome of the labor supply model, and expected taxes in the hours outcome of that model.

The effect of the respondent's wage income on labor force withdrawal was examined by performing two probit estimations. In the first probit analysis, two variables—average annual earnings up to the earnings test maximum and earnings test status (above or below the maximum)—were used in the full model estimation. These two variables were replaced in a second analysis with an imputed wage rate. The imputations were made by applying a wage equation that was developed using multiple regression procedures on a sample of full-time workers. All of the explanatory variables from the first probit analysis were included as factors in the wage equation. Consistent results were obtained with both probit analyses.

Model Simulation

The labor supply model was used to estimate the effects of alternative earnings test policies on annual work effort by changing the values of the expected tax predictor to correspond with hypothetical policy changes and comparing results to baseline predictions.

Model Review

The model likelihood value and standard errors for each predictor were included in the model documentation. R^2 values were provided for the least squares regression equations. Results from the model were theoretically plausible.

This model was used to simulate the effects of alternative social security earnings test policies. It is one of the earliest models of the retirement decision and can be viewed as more exploratory in nature, with respect to operationalizing life cycle theory, than some of the more recent models.

References

PELLECHIO, A. The Effect of Social Security on Retirement. Cambridge, Mass.: National Bureau of Economic Research, 1978.

———. The Social Security Earnings Test, Labor Supply Distortions and Foregone Payroll Tax Revenue. Cambridge, Mass.: National Bureau of Economic Research, 1978.

Quinn Model

Background and Use

The Quinn model was developed primarily to analyze the roles of health status and eligibility for retirement benefits on the decision to withdraw

from the labor force. Documentation of model estimates for wage and salary workers was published in 1977 and for self-employed workers in 1980. The model has not been used formally for forecasting or the analysis of public policy issues and there are no plans for such use or for further updating of the model. Further information is available from its developer: Joseph F. Quinn, Department of Economics, Boston College, Chestnut Hill, MA 02167.

Model Description

Data Source

The sample used for the Quinn model estimations consisted of 4354 wage and salary workers (version A) and 836 self-employed workers (version B), all of whom who were white married male respondents to the 1969 RHS. These samples were partitioned into healthy and health-limited workers for some of the model estimations. All sample respondents were between the ages of 58 and 63 inclusive. Two additional estimations of the model (version C) were based on sub-samples of the self-employed workers. One of these used 660 self-employed workers who retired between 1969 and were out of the labor force in 1969 and re-entered between 1969 and 1971.

Model Specification

For this model, retirement was defined as complete labor force withdrawal and was measured by categorizing each individual as either in or out of the labor force. All estimations were done using multiple regression and logit procedures to explain labor force status from a set of personal financial and other characteristics. The same set of financial characteristics was used to model the behaviors of both wage and salary and self-employed workers. Other characteristics included in the model varied depending on the sample composition.

The financial variables included in the model were wage rate, either imputed or observed, 2) asset income, not including retirement benefits, 3) eligibility for social security benefits, and 4) eligibility for private pension benefits. Health and the presence of dependents in the home were included in all estimations. In addition, job characteristics and local labor market conditions were included in estimations based on samples of wage and salary workers.

Two estimations of the model examined labor force transition behavior among self-employed males—withdrawal from or re-entry into the labor force during the transition period 1969-71. For these estimations, two additional explanatory factors were included: changes in either health status or social security eligibility that occurred in the transition period.

Model Review

Overall model R^2 values for each estimation are reported in the model documentation. The documentation also includes approximate significance tests for each predictor. We question the validity of the statistical tests given the imprecision with which the standard errors of the predictors were measured, a problem acknowledged by the developer.

The developer reported that the model equations were re-estimated on reduced samples using a nonlinear maximum likelihood logit technique with qualitatively comparable results.

This model has not been used for forecasting or policy experimentation. It is unique in providing information on retirement decision making among the self-employed and on the effects of job characteristics on retirement. It is one of the earliest models of the retirement decision and can be viewed as more exploratory in nature—attempting to identify explanatory variables—than some of the more recent models.

References

QUINN, J. F. "Microeconomic Determinants of Early Retirement: A Cross-sectional View of White Married Men." Journal of Human Resources, 12:3 (1977), 329-46.

———. "Labor-Force Participation Patterns of Older Self-Employed Workers." Social Security Bulletin, 43:4 (1980), 17-28.

Schmitt-McCune Model

Background and Use

The Schmitt-McCune model was developed in 1979 and revised in 1981 to examine the effects of job attitudes on the retirement decision. The model has not been used for forecasting or public policy analysis and the developers have no plans to further revise or use the model. Further information is available from its developer: Neal Schmitt and Joseph T.

McCune, Department of Psychology, Michigan State University, East Lansing, MI 48824.

Model Description

Data Source

This model was estimated for two samples of Michigan civil servants. The first sample consisted of 672 individuals aged 55-64 who were eligible for full retirement benefits in the survey year. The second sample consisted of 143 individuals, some from the first sample plus similar individuals over age 64, who had not yet retired and who responded to a follow-up survey one year later.

Model Specification

The first version (A) of the model examined the effects of a set of demographic, health, financial and job attitude variables on the retirement decision which was defined as leaving the main job and accepting a pension. Discriminant analysis procedures were used to estimate the model and differentiate between retirees and non-retirees.

The revised version (B) of the model used stepwise discriminant analysis procedures to study the effects of a similar set of variables on the subsequent retirement decision of a sample of workers.

All individuals in the sample were eligible for full pension benefits from the state of Michigan, so the effects of pension benefits on the retirement decision were partly controlled. The workers' knowledge of their eligibility for the pension was included as a factor in the model. The size of the benefit was not assessed. Information concerning potential social security benefits or other private pension benefits was also not assessed. However, the model did include measures of expected retirement income and its perceived adequacy, at present and at age 65. Other financial variables included current wage rate, the employment status of the spouse, perceived income needs and the importance of retirement income to the worker.

Three measures of health—number of illnesses, number of doctor visits and self-assessment of health status—were included in the model. Demographic variables included age, sex, race, marital status, number of dependents, education, job level, community size and length of residence in the community.

Job attitudes included in the model were the desire to work, job satisfaction, job involvement, job motivating potential and the extent of feedback from others that is given on the job. Job satisfaction, job involvement and job motivating potential were measured as scores on standard psychological instruments containing more than one question which were developed outside of the model development process by other investigators.

Model Review

Validity tests reported in the documentation included the canonical correlation between the outcome variable and the entire set of predictors, a chi square test of the accuracy of the model's classification of individuals' retirement status, canonical correlations for subsets of predictors, and internal consistency measures of the reliability of the multiple item scales.

This model has not been used for policy experimentation or forecasting. It is unique in modeling the effects of job attitudes on the retirement decision. However, it has limited generalizability, focusing solely on Michigan civil servants.

References

SCHMITT, N., et al. "Comparison of Early Retirees and Non-retirees." Personnel Psychology, 32 (1979), 327-40.

SCHMITT, N., and J. T. McCune. "The Relationship Between Job Attitudes and the Decision to Retire." Academy of Management Journal, 24 (1981), 795-802.

Slade Model

Background and Use

The Slade model was developed in 1982 to examine the effects of social security and other variables on changes in labor force participation over time. The model has not been used for forecasting or public policy analysis. Further information is available from its developer: Frederic P. Slade, Department of Economics, Rutgers University, Hill Hall, 8th Floor, Newark, NJ 08817.

Model Description

Data Source

The estimation sample was drawn from the 1969-71 RHS and included 2991 men aged 58-62 in 1969 who were fully insured under the OASDI program.

Model Specification

For this model, retirement was defined as withdrawal from the labor force in the transition period 1968-70. Maximum likelihood probit procedures were used to estimate retirement status as a function of several variables.

Background characteristics included in the model were race, age, education, marital status, whether the respondent changed addresses in the transition period, and health limitations existing in 1969 or acquired in 1971. Economic characteristics included 1969 assets, hourly wage rate, potential disability benefits and potential social security benefits and changes in all four economic variables in the 1968-1970 transition period.

A similar model was developed to estimate entry into the labor force after absence in 1968.

Model Review

The model documentation included the likelihood value associated with the model and test of significance for individual predictors, statistics which indicate the model's validity. Results from the model were defined by the developer as preliminary, based on the short time horizon used to observe behavior (two years). He noted that they were not entirely theoretically plausible.

This model has not been used for policy analysis or forecasting. The developer noted that a revised version of the model based on subsequent RHS data collections would be more useful than the present version. We do not know if such a revision is being done.

Reference

SLADE, F. P. Labor Force Entry and Exit of Older Men: A Longitudinal Study. Cambridge, Mass.: National Bureau of Economic Research, 1982.

Appendix IV

Models of Retirement Income

In this appendix, we describe four models, one of which has multiple versions, developed to forecast retirement income. These four models—DYNASIM, PRISM, MDM, and the AARP Age-Income Model—are computerized forecasting models that have been applied for public policy analysis, maintained since their original development and are available for use.[1]

This class of models describes many aspects of the retirement income system, including characteristics of individuals, of the labor market and of the programs which distribute retirement income. The non-income predictions (estimates of population size, and labor market behavior, for example) of these models are input to other models. In some instances, their estimates of benefits paid out by a particular program are used to produce cost estimates. The primary focus of these models, however, is on predicting income.

Model descriptions on the pages that follow (see table IV.1) are presented following the outline given in appendix I. Each description was reviewed for accuracy by the model developer and all identified errors were corrected. A summary of the individual model descriptions is provided in chapter 4 of the main volume of this report.

Table IV.1: Identification of Income Models

Model	Page
DYNASIM - The Dynamic Simulation of Income Model	133
PRISM - The Pension and Retirement Income Simulation Model	139
MDM - The Macroeconomic-Demographic Model	143
AARP - Age Income Model of the Elderly	151

[1]Our assessment of availability was made in 1984 at the time of our data collection. HHS has advised us that MDM is not currently (1986) available. For details, refer to their letter to us which is reproduced in the appendices to the main volume of this report.

DYNASIM (The Dynamic Simulation of Income Model)

Further information about this model is available from its developer: The Urban Institute, 2100 M Street, N.W., Washington, DC 20037

Background and Use

DYNASIM was developed as a general purpose analytic tool to make forecasts on a wide range of income related government programs. The model was originally used to make projections for the AFDC (Aid to Families With Dependent Children) and social security programs. The AFDC projections were 10-year forecasts of costs and caseloads. The social security projections were 25 year forecasts of the distributional impact of OASI benefits.

In recent years, the model has been used almost exclusively for the examination of retirement-related issues. In 1982 the Urban Institute used the model in connection with the Brookings Institution Conference on Retirement and Aging to examine potential changes to the private pension system. The model was used to examine four scenarios for the private pension system: 1) continuation of the present system, 2) universal coverage under OASI, 3) pension portability, and 4) price indexing of benefits.

DYNASIM was also used by the American Association of Retired Persons in connection with proposed changes to the social security system prior to the adoption of the 1983 Social Security Act amendments. Since the passage of the 1983 amendments, the model has been used by the Urban Institute to examine their long-run effects.

More recently, the model has been used by the Assistant Secretary for Planning and Evaluation (HHS), the Social Security Administration, and the Urban Institute to examine the distributional consequences of an earnings sharing system under the OASDI program.

We have identified six microsimulation models which grew out of the original DYNASIM project at the Urban Institute. The original model, funded by the Department of Labor, was developed between 1969 and 1976. The version of the model reviewed here is DYNASIMII, the second generation, developed at the Urban Institute in 1983 under funding from the Congressional Budget Office and the Department of Labor. Although the structure of the individual components of the original model remains very much the same, many components were reestimated with more

recent data for the revised version of the model. This latest version includes changes in the social security program which resulted from the 1983 amendments to that program.

In addition to the Urban Institute, The Congressional Budget Office (CBO) and The Office of the Assistant Secretary for Planning and Evaluation (ASPE) in the Department of Health and Human Services are currently using DYNASIMII. CBO uses the Urban Institute's model intact, while users at ASPE have modified some of the model components and have replaced the social security benefit and tax calculator with one they developed.

The Department of Labor's (DOL) version of the model, PENSIM, is also descended from the original DYNASIM. DOL split the original version into a number of sub-models (as have the other versions) and revised the job change and pension assignment algorithms. They use PENSIM for in-house analysis of issues only—the results are not included in formal DOL reports.

Mathematica, Inc. developed MICROSIM, another version of the original DYNASIM model that was less costly than the original model to run. The Social Security Administration currently uses a descendent of this model.

The University of Michigan is currently developing a microsimulation model similar to DYNASIM. They are concentrating on linking their model to a macroeconomic model to allow for interaction between macro and micro level responses. ASPE, which is funding the Michigan project, plans to incorporate some of the components of the Michigan model into their version of DYNASIMII.

The description and review which follows is based on DYNASIMII at the Urban Institute. Most of our remarks generalize to the other versions of the model.

Model Description

DYNASIMII is divided into two major submodels: The Family and Earnings History Model (FEH) and the Jobs and Benefit History model (JBH). The FEH model takes an initial sample population and processes it year by year through a series of simulated life events (birth, death, marriage, etc.). The output of the FEH model is a synthetic longitudinal record of the demographic and labor force history of every individual in the sample. The second model (JBH) takes these records, simulates additional

labor force history detail and calculates private pension benefits, individual retirement account accumulations, and social security benefits for each individual in the sample. This output from the JBH model is then aggregated by population demographic characteristics to provide forecasts of the distribution of retirement income.

Many of the aggregated outcomes of the model are constrained to conform to specified macro-level assumption values. The mechanism for these constraints differs for different modules in the model. Results in labor force behavior modules are constrained by user controlled adjustment factors. For example, the average wage rate is controlled by a scale factor added on to the wage rate equation for each individual. In this instance the user does not supply the targeted macro value of the wage rate. Rather, the adjustment factors are manipulated until the desired macro value is reached. Many assumptions used to constrain model output are taken directly from the II-B assumptions in the most recent OASDI Trust Fund Report.

Family and Earnings History Model (FEH)

The 1973 CPS-SER Exact Match File is the data source for the initial DYNASIM sample. The DYNASIM sample consists of approximately one half of that file. Before a simulation is run, certain adjustments are made to the sample data. Variables included in the model but not available in the CPS file are imputed from other sample characteristics. Imputed variables include for example, the number of times a woman was ever married. In addition, the sample is arranged into nuclear families which become the basic unit of analysis in the FEH model. DYNASIM documentation suggests that the initial sample could be obtained from a large number of household surveys which contain the relevant family and individual characteristics.

Aside from the initial CPS sample, DYNASIM uses a variety of other data sources. The majority of the labor force behavior equations were estimated with data from the Panel Study of Income Dynamics. Other data sources include U.S. Public Health Service's Vital Statistics for 1969, 1981 CPS data, and the results from estimations of other researchers.

The FEH model is itself composed of fourteen modules each of which simulates some life event or condition. The complexity of these modules ranges from a simple probability table to a series of empirically estimated regression equations. Individuals in the sample are exposed to each of the modules for every year of the simulation, except where not appropriate. For example, a married individual would not be exposed to

the marriage module which simulates marriage for singles. The fourteen modules simulate death, birth, marriage, leaving home, finding a mate, divorce, education, mobility, disability, labor force participation, hours in the labor force, wage rate, and unemployment.

The outcome of each of the modules is determined by various predictors. Often the same predictors are used to determine more than one life event. Among the more common predictors which determine outcomes in the FEH modules are age, race, sex, education, marital status, number and age of children. The output of the FEH model is a labor force and demographic history for each individual in the sample. These labor force histories are a major outcome of the model, and are themselves used by others for analyses.

Jobs and Benefits History Model (JBH)

The simulated labor force and demographic history which was the output from the Family and Earnings History Model is the primary data source for the JBH model. The model also uses information from the January 1973 CPS, the May 1979 CPS, and the 1974 Bureau of Labor Statistics Defined Benefit Plan Survey.

Like the FEH model, the JBH model is composed of a number of submodels. The Jobs submodel predicts a number of characteristic of an individual's work history which were not determined in the FEH model. This submodel contains modules which simulate job change, industry of employment, pension coverage, pension plan characteristics, and pension plan participation.

The Employer Pension Submodel contains modules which predict benefit eligibility, assign a benefit calculation formula, and compute benefits. Other retirement income sources are determined in the Social Security and Individual Retirement Account submodels. For the Social Security module, retirement, disability, spouse, and children's benefits are calculated. Participation, accumulation, and distribution are determined in the IRS module.

The third submodel is the Retirement Decision module which uses much of the previously simulated information to predict the age of retirement. (The Retirement Decision module is based on the Burkhauser-Quinn model described in appendix III.)

In the final modules, Supplemental Security Income benefits and federal income and payroll taxes are calculated. These calculations are only done for the final year of the simulation.

As with the FEH model, the modules in the JBH model use a variety of estimation techniques and a variety of predictors. Important predictors in the JBH modules include age, industry of employment, years of service at individual jobs, disability status, marital status, income, wage rate, and social security and private pension wealth.

The final output of the JBH model provides persons by person information on income which can be broken down by its various sources (earnings, private pensions, social security, IRAs). This information is available for the final year of the simulation as well as other years specified by the model user. The distribution of income can be tabulated over a number of different sample characteristics (such as age and sex). In addition to these annual cross-sectional snapshots, it is also possible to report individual longitudinal results.

Model Review

Documentation

The Urban Institute's version of DYNASIM II is formally documented. (Users of version of DYNASIMII—HHS, DOL and CBO—have not formally documented their changes to the model.) DYNASIMII documentation is divided into two volumes: Volume I (Johnson, et al., 1983) describes the Family and Earnings History Model, and Volume II (Johnson and Zedlewski, 1982) describes the Jobs and Benefits History Model. These two volumes also refer to the original DYNASIM documentation (Orcutt, et al., 1976). The documentation is difficult for the novice to read because there is a fair amount of technical detail on the derivation of probabilities for each of the modules. In addition, for many details concerning the model it is necessary to refer back to the original documentation.

Our description of DYNASIM is based largely on information provided in the documentation, which we found to be fairly complete for this purpose.

Maintenance

Each of the developers of the different versions of DYNASIM have worked on revising different components of the model. Across versions, most of

the effort in revision involved trying to get the model to run more efficiently in order to reduce costs. Because of this effort the original approach to modeling remains intact although parts of the model have been reestimated with new data or have experienced some structural change. The extent of revision varies across the different versions of the model, and in most cases appears to be associated with specific uses of the model. Although maintenance and updating activities are occurring, there are no routine provisions for those activities, and there is little, if any, coordination of effort among those with different versions of the model. This suggests that the model will most likely need to be updated or revised in some manner prior to using it for analysis of new issues.

Validity

We found little information on DYNASIM's operational validity. For some of the individual modules which use the results of regression analysis, validity measures such as r-square or the standard error are reported. No information on the operational validity of the entire model (sensitivity analyses, or accuracy) is available. A discussion of the model's theoretical validity is available (Haveman and Lacker, 1984).

Use

DYNASIMII and other versions of the original model have been used and continue to be used to answer questions about retirement programs with the most recent emphasis on social security. Forecasts produced by what appears to be the same model (DYNASIMII at the Urban Institute or DYNASIMII at ASPE) could be based on differing assumptions and subtle structural differences and might produce different outcomes. There is no standard model and no understanding or study of how differences in the various versions affect their output.

The model's strength is in the demographic detail used to predict labor force activity. It is therefore most useful for addressing questions concerning the future distribution of retirement income across sub-populations. Some caution should be used in interpreting or relying solely on its forecasts, given the lack of information on operational validity.

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PRISM (The Pension and Retirement Income Simulation Model)

Further information about this model is available from its developer: ICF, Inc., 1850 K St., N.W., Suite 950, Washington, DC 20006.

Background and Use

PRISM was developed in 1980 for the Department of Labor and the President's Commission on Pension Policy to study a Mandatory Universal Pension System (MUPS) and to answer questions on who might end up without a pension under such a system and what the distribution of income might be under alternative MUPS proposals. In 1981 the model was revised for the American Council of Life Insurance to examine what the distribution of pension benefits would be under various alternative trends in pension coverage. The model was revised again in 1982 for the Employee Benefit Research Institute to run simulations of various social security reform proposals. Results from these simulations were presented in testimony in 1983 to the House Committee on Ways and Means for hearings on the proposals of the National Commission on Social Security Reform.

The current version of PRISM includes revisions made in 1983 for the American Council of Life Insurance and the Department of Health and Human Services in connection with the Brookings Project on Retirement and Aging. The model was revised to incorporate 1983 legislated changes to the social security system and to update macroeconomic forecasts of employment and earnings. The model was revised in 1985 to incorporate provisions of the 1984 Retirement Equity Act. The revised model was used in 1985 to analyze the impact of specific provisions of the Retirement Equity Act and potential changes in vesting.

Model Description

PRISM simulates the distribution of income for the following components of retirement income: earnings, social security, public retirement plans, private retirement plans, individual retirement accounts and supplemental security income. The model also calculates state and federal income taxes in order to forecast disposable income. The model is currently designed to produce forecasts through the year 2030.

PRISM is divided into two sub-models—the Work History Model which simulates demographic and labor force information and the ICF Retirement Income Simulation model which calculates the various sources of retirement income based on the labor force histories determined in the Work History Model.

PRISM controls its aggregate estimates of employment, hours worked, and wages for various age-sex groups, so that these estimates correspond to results of the ICF Macroeconomic-Demographic Model (described later in this appendix). Some adjustments are necessary as the variables predicted by the Macroeconomic-Demographic Model do not directly correspond to those determined in PRISM.

Work History Model

The output of the Work History Model is a longitudinal record for each individual in the sample indicating health and family characteristics, labor force activity, pension coverage and benefit acceptance.

The primary data source for the Work History Model is the ICF Pension/Social Security Data Base which contains information on 28,000 individuals. This data base synthesizes information from the March 1978 CPS-SER Exact Match File, the March 1979 CPS and the May 1979 CPS Pension Supplement. The file contains 1979 pension information, 1977-79 employment information, 1977-78 income data, and annual taxable earnings from 1951-77. For approximately 8,000 individuals in the

sample, no information on pensions, labor force history, or earnings history was available. This information was imputed from other sample characteristics for those individuals. The individuals in the sample are organized into family units, the basic unit of analysis in PRISM.

A second data source, the ICF Retirement Plan Provisions Data Base, contains a sample of actual retirement plans which are used for the calculation of employer pension benefits. Private plans were sampled from a Department of Labor data base containing information on all single-employer plans filing Form 5500 in 1981. Public employer plan sponsors were sampled from a Census Bureau listing of public plan sponsors.

The data sources used to develop probabilities in individual modules include: Social Security Administration alternative II-B assumptions, Social Security Administration data on disability claims, and information from additional Current Population Surveys.

The Work History Model simulates three types of information: health and family characteristics, labor force activity, and pension and social security benefit accumulation and acceptance. Under "health and family characteristics," mortality, disability, marital status, and childbearing are simulated. Simulated for "labor force activity" are hours worked annually, wage rates, job change, and industry of employment. Pension coverage, plan assignment, employer benefit pension acceptance, and social security benefit acceptance are predicted last.

Event probabilities are assigned to each individual for each event. These probabilities are a function of a number of characteristics of that individual. Characteristics used include: age, sex, disability status, number of children, marital status, education, hours worked, industry of employment, and wage.

ICF Retirement Income Simulation Model

The output of this submodel is the projected distribution of income for the elderly by the various components of retirement income, and various characteristics of the population (age, sex, etc.) for specified years.

The longitudinal records produced by the Work History Model are the primary data source for this submodel.

All individual behavioral events are determined in the Work History Model except for IRA participation, contributions, and accumulations which are determined in the ICF Retirement Income Simulation Model.

This model uses previously-developed (simulated and actual) information to calculate the income individuals will receive from social security, employer-sponsored pension plans, IRAs and Supplemental Security Income. In the final step, the model calculates federal and state income taxes and social security payroll taxes to determine disposable income.

Model Review

Documentation

The most recent version of the PRISM documentation was published in February 1984. In addition to description of the various model components, the documentation contains a chapter with detailed information on the primary data bases and a chapter which summarizes some of the key assumptions of the model. Our description of PRISM is based largely on information provided in the documentation, which we found fairly complete for this purpose.

Maintenance

The model has had four major revisions since its development in 1980. Each of the revisions was in connection with specific use of the model for new projects. There are no provisions for routine updating and revision of the model. This suggests that the model may need revisions or updating prior to using it for analysis of new issues.

Validity

We found no information on what procedures, if any, are used to examine the operational validity (accuracy or sensitivity analysis) of the model. An assessment of the theoretical validity of each of the modules is available (Haveman and Lacker, 1984).

Use

PRISM is well documented, has been maintained and used in the past, and is available for further use in the future. The model has been used with an emphasis on private pension benefits although it does calculate other components of retirement income. To this end, the model attempts to capture the intertemporal nature of work patterns (which are important in the calculation of benefits), and is unique in its use of actual pension plans to calculate benefits. The model is also unique in its use of a macroeconomic model to control aggregate results.

PRISM is most useful for addressing questions concerning the future distribution of retirement income across sub-populations. Its limitations are that it is a streamlined model which does not account for the influence of some demographic factors (race, for example) on outcomes and, as is the case with other microsimulation models, the operational validity of the model remains largely untested. Appropriate caution should be used in interpreting or relying solely on its forecasts.

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MDM (Macroeconomic-Demographic Model)

Further information about this model is available from its developer: ICF, Inc., 1850 K St., N.W., Suite 950, Washington, DC 20006.

Background and Use

MDM was originally developed by ICF in 1981 for the President's Commission on Pension Policy to examine the impacts of raising the normal retirement age and instituting a Mandatory Universal Pension System. The National Institute on Aging (NIA) has assumed responsibility for maintaining the model since that time. ICF prepared a report for NIA in 1982 using the model to examine a wide variety of policy issues (alternative mortality and fertility scenarios, changes in the average age of retirement, alternative economic assumptions concerning productivity growth, and changes in total payments to social security and private pensions) and the implications of these issues for retirement income. The model has also been used by the Commission on Employment Policy at the Department of Labor.

ICF uses MDM to provide information on wages and employment for their Pension and Retirement Income Simulation Model (discussed earlier in this appendix).

NIA plans to use the model in the future for the analysis of social security legislation and to investigate various scenarios on population aging and how each affects the retirement income system. They also hope to integrate MDM with a model of health expenditures to study health issues. The model is currently being revised for these purposes by ICF. Planned changes include: the inclusion of more recent data, (e.g., use of new data bases, such as the Survey of Consumer Finances) and incorporation of recent legislation affecting retirement income, such as the Economic Recovery Tax Act of 1981 and the 1983 amendments to the Social Security Act.

Model Description

MDM produces forecasts of retirement income by emphasizing demographic trends and the long run productivity capacity of the economy. A population model and a long-run economic growth model form the core of MDM. In addition to producing forecasts of various components of retirement income, the model produces, in intermediate steps, forecasts of population size, labor market behavior, and general economic trends. Although it is a macro-level model, results are presented for twenty-two age-sex groups.

MDM is composed of eight sub-models. One is a population model; two model the macroeconomy; and, five model particular elements of the retirement income system. The population model serves as input to the macroeconomic growth and labor market models. These two models, which are solved simultaneously, serve as input to the retirement income models which calculate various components of retirement income. The individual models are described below.

Population Model

The population model produces annual projections of population size.

Currently, the model uses 1980 U.S. Census estimates to form a base year population disaggregated by age, sex and race. Census fertility, mortality and immigration rates are also used.

The population model uses the Census Bureau's projection methodology: rates of fertility, mortality, and immigration for each age-race-sex group are applied to the base year population to determine the population in

the year following the base year. The population is updated each year based on the previous year's population, and the specified rates of fertility, mortality and immigration.

Macroeconomic Growth and Labor Market Models

The primary output of these two models is annual information on the labor force by sex and age (e.g., size, labor force participation, unemployment, average hourly wage, etc.). In addition, information on macroeconomic variables (GNP, investment, consumption, etc.) is available, although this information is not as directly relevant in the eventual determination of retirement income.

Population projections from the population model, and numerous exogenous variables are the main data sources for these models.

The macroeconomic growth model is based on the Hudson-Jorgensen long-term macroeconomic model of the U.S. economy. This model differs from conventional macroeconomic models (like the Data Resources, Inc., quarterly model) which concentrate on short-term fluctuations in aggregate demand. Instead the MDM macroeconomic model focuses on the determinants of long-term economic growth such as the supply of capital and labor, and productivity changes.

The labor market model (developed by Joseph Anderson) is solved simultaneously with the growth model. It models the supply, demand, use, and wage for each age-sex group.

Both models consist of a series of empirically estimated regression equations, and identities, which are solved as a simultaneous system.

Social Security Model

The Social Security Model forecasts the future number of beneficiaries by age, sex and benefit type; average retirement and disability benefits for primary and secondary beneficiaries; total benefits paid; payroll taxes collected by each age-sex group; and trust fund balances.

Population estimates by age and sex from the Population Model and estimates of compensation for each age-sex group from the Labor Market Model are the primary data sources for the model. Some results are constrained to forecasts from the OASDI cost estimate models (described in appendix II).

Contributions are estimated using a methodology similar to that used by the SSA Office of the Actuary: converting total compensation to an appropriate tax base by taking into account non-covered employment, the upper limit on taxable earnings and other factors.

The average benefit is calculated every year for those retiring or becoming disabled in each age-sex group. It is based upon the earnings history (average annual earnings) which is calculated by the Labor Market Model. This benefit level is then adjusted to correspond with SSA estimates. It is then averaged with the benefit of those retired and disabled in previous years, and finally multiplied by the estimated number of primary beneficiaries to predict the total amount of primary benefits. Average secondary benefits are based on the primary benefit estimates. The number of secondary beneficiaries is not independently modeled but it based on SSA estimates.

Private Pension Model

This model forecasts the number of covered, participating, and vested workers by type of plan (defined benefit, defined contribution, individual plan); total contributions for each of the three pension plan types; the number of retirees, by age, sex and pension plan type (or no plan); total benefit payments for each of the three pension plan types; the average benefit per retiree by age, sex and number of years retired, for each of the three pension plan types; and the level of assets held by each plan type.

Estimates of average wages by age and sex and estimates of total workers by age and sex from the Labor Market Model are data sources for this model. Initial values for number of retirees, pension assets, and various other parameters such as retirement rates, rates of return, are also input to the model. Coverage, participation, and vesting rates are based on the Special Pension Supplement to the May 1979 CPS. Distribution of pension plan types is based on the 1975 DOL Form EBS-1 filings. Cohort retirement behavior is based on the May 1979 Current Population Survey and Pension Facts, 1980.

The numbers of covered, participating, and vested workers are estimated by applying age-sex specific coverage, participating, and vesting rates to each of 20 age-sex groups. All rates are assumed constant over time. Covered workers are also distributed across three plan types: defined benefit, defined contribution, or individual plans (IRA, Keogh). All age-sex groups are assigned the same distribution of plan types.

Average contributions for each age-sex group are calculated differently for defined benefit and defined contribution plans. For defined benefit plans, a benefit of one percent of average annual salary is assumed. Once the benefit has been determined, the normal cost is determined using the Accrued Benefit Cost Method. Mortality, turnover, and real return (1.85 percent) assumptions enter the calculation. A normal retirement age of 65 is assumed. Contributions for defined contribution plans are based on a rate of 8.4 percent of average annual salary which is assumed to begin at age 34 and continue until retirement. A real return of 1.85 percent on pension assets is assumed.

The model estimates the number of new recipients every year by age and sex and distributes them among the three plan types. Number of retirees from previous years is adjusted by including mortality assumptions. Benefit acceptance is assumed to increase over time, as coverage increases.

An average benefit is calculated for each age, sex, year of retirement, and type of plan category. For defined benefit plans, the formula is one percent of career average compensation. For defined contributions, benefits are based on contributions and interest accumulations.

Pension Plan assets are also calculated. For a given year, they are assumed equal to last year's assets plus contributions and interest minus benefits paid.

Public Employee Pension Model

This model forecasts the future number of employees by age and sex in each of seven sectors of public employment; number of covered, participating, and vested workers in seven sectors of public employment and those covered by no pension plan; number of retirees by age, sex and sector of employment; total annual benefits paid by public employee pension plans; total annual contributions and assets for those plans operated on a funded basis; and average benefits for each plan.

Average annual wages, by age and sex; total civilian employment by age and sex in the private and public sectors; population age 5 to 17, which is used to estimate numbers of state educators; and total income, which is used to estimate numbers of hazardous duty and state and local administrative workers are inputs to the model.

Data sources include BLS Employment and Earnings Statistics, projections from the Labor Market model, 1979 Civil Service age and tenure

data, the May 1979 CPS Pension supplement, and other sources described in the model specification section.

Public employment is divided into six sectors in this model: Federal Civil Service, military enlistees, military officers, state and local hazardous duty workers (police and firefighters), state and local general and administrative workers, state educators, and local educators. All covered public sector employees are assumed to be in defined benefit plans.

First, total public employment by sector is estimated. This is based on BLS Employment and Earnings statistics as well as age-sex private sector projections from the Labor Market Model. Second, coverage, participation, and vesting are projected based on program regulations (e.g., universal OASDI coverage of Civil Service and Military workers).

Third, for the Civil Service employees, and state and local plans, contributions are estimated (the other plans are not funded). This is done using a modified accrued benefit cost method with Census Bureau mortality rates, T-6 turnover rates, a 1.85 percent return on pension assets, a 1.8 percent growth in real wages, and average compensation levels from the Labor Market Model.

Fourth, number of new recipients each year is based on age-sex specific retirement rates. For the Civil Service, they are taken from the 1979 Federal Civil Service Retirement System Actuary's Report. Military rates are from unpublished DOD data, and state and local rates are derived from the May 1979 CPS Pension Supplement. The number of previous recipients is adjusted for mortality based on assumptions derived by the SSA Office of the Actuary.

Fifth, benefits are calculated based on different formula for each of the seven sectors. The formulae are applied to the average compensation for each age-sex group generated by the Labor Market Model.

Finally, pension plan assets are calculated for the funded plans. The assets are equal to the previous years assets, plus contributions, plus earned interest, minus benefits paid.

Supplemental Security Income Model (SSI)

This model forecasts expenditure levels for the SSI program by age and sex of recipient.

Estimates of aggregate real income per capita and age-sex specific compensation levels from the Labor Market Model and age-sex population estimates from the Population Model are data sources for this model. Other inputs include data on the blind and disabled portion of the population from the 1975, 1976, and 1977-79 Statistical Supplements to the Social Security Bulletin and the Current Population Reports Series P-25, Nos. 614, 870.

SSI benefits are calculated in three stages. First the size of the participant population is determined. This is done by assuming that the shape of the overall income distribution does not change over time. As the mean level of real income increases over time, the number of SSI participants declines because eligibility is based on a constant real income level. The SSI population is determined by integrating over that part of the distribution below the eligibility level.

Average real benefits are assumed constant over time and are based on recent benefit levels. Total benefits are calculated by multiplying the average benefit by the number of recipients.

Disabled and blind benefits were calculated by assuming the proportion of the population in these categories will remain constant over time, and that real benefit levels will also remain constant. Again total benefits are calculated by multiplying the number of recipients by the average benefit.

Medicare Model

This model forecasts expenditure levels for the Medicare program by age and sex of recipient for each type of service.

Population estimates by age and sex from the Population Model and average income levels by age and sex from the Labor Market Model are inputs to this model.

Cohort-specific real per-capita spending rates for 26 age-sex groups are applied to the population of that group in each year to determine Medicare spending by type of service (inpatient hospital care, home health care-Part A, home health care-Part B, outpatient care, skilled nursing home care, physician services and other medical care). The spending rates are based on published and unpublished tables for 1966-77 by the Office of Research, Demonstrations, and Statistics in the Health Care Financing Administration. The same rate for each cohort is used for the entire length of the simulation.

Model Review

Documentation

The documentation for MDM is well-written. It contains concise, understandable verbal descriptions of the model, its data sources, processes, and assumptions. It also contains an appendix with a sample output for each of the sub-models, a very helpful resource for understanding what the model can do. We based our description of MDM largely on the documentation and found it fairly complete for this purpose. Other model documentation, including a user's manual, is available although we did not review it.

Maintenance

Although the model has undergone some revision since its creation, there are not regular provisions for maintenance and update. The model is currently undergoing a major revision and update by ICF, Inc. The revised model is targeted for use in 1986.

Validity

MDM documentation includes the results of backcasting various outcomes for the years 1970-1979 as one test of model validity. It also compares forecasts of certain outcomes with similar forecasts made by the OASDI cost estimate model (which we review in an earlier appendix) and the Bureau of Census. Developers report that they have conducted but not published other analyses of validity, such as testing the validity of estimated equations.

Use

MDM is specifically designed to make long range forecasts of the levels of various sources of retirement income for 22 age-sex groups. It emphasizes demographic trends, and long run economic growth. In the process of forecasting income, it also provides forecasts on other variables of possible interest for the analysis of retirement policies: population by age and sex, labor force characteristics (hours worked, hours unemployed, wage, etc.), macroeconomic trends, as well as the number of beneficiaries of various retirement programs.

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AARP Age-Income Model of the Elderly

Further information about this model is available from its developer: Data Resources, Inc. (DRI), 24 Hartwell Avenue, Lexington, MA 02173.

Background and Use

The AARP Age-Income model was developed from the Data Resources, Inc., (DRI) Demographic-Economic Models (DECO) which are used to forecast income from demographic sub-groups of the U.S. population. The family-based DECO Model, which creates inputs for the AARP Model of the Elderly, was developed at DRI in 1976. The structure of this model is based on work compiled by Charles E. Metcalf in An Econometric Model of the Income Distribution (University of Wisconsin, 1966). DRI's version of the model interrelates economic changes in income, unemployment, and labor force participation with socio-economic shifts in marriage and divorce and broad demographic movements to evaluate family formation and the distribution of income. These characteristics are modeled for six age groups and five family-size groups. The AARP commissioned the development of the AARP Age-Income Model to provide greater detail on the elderly portion of the Family DECO Model.

The AARP Age-Income Model uses the same method as the DECO model, but focuses on those aged 55 and over. Forecasts from the Age-Income Model first appeared in the 1981 DRI publication, The Elderly and the Future Economy, which included 25-year forecasts of the income of the elderly under different macroeconomic scenarios. The model is updated each year and may be used to simulate the potential impacts of public policy revisions on the future income of the elderly. In addition it has been used to analyze the effect of various proposed changes in cost of living adjustments (COLAs) for social security benefits. The results from this type of analysis were the basis for AARP's testimony at the House and Senate hearings which led to the adoption of the 1983 social security amendments. AARP has recently released an analysis of the effect of proposed changes in Social Security COLAs for the federal 1986 fiscal year budget based on the Age-Income Model.

Model Description

The AARP Age-Income Model is used to forecast the income distribution for twelve sub-groups (based on age, sex, and family status) of the population aged 55 and over. Each fall, the model is updated and a new forecast and report is prepared by DRI for the AARP. Alternative forecasts are calculated in response to proposed public policy changes which could have an impact on the income of the elderly.

The Age-Income Model is essentially a static model which can estimate the distribution of income for sub-groups of the elderly for a given set of economic and demographic variable specifications. It can be used to generate forecasts by taking as inputs future values for the demographic and economic variables which are forecast by the DRI quarterly macroeconomic model and the DRI Demographic-Economic model.

The 12 demographic sub-groups for which income forecasts are generated are comprised of individuals aged 55-61, 62-64, 65-71, 72+, each subdivided according to sex and family status: single male, single female, or two or more related individuals. For each sub-group, the model is used to forecast: (1) the total number of individuals in that sub-group, (2) the real mean annual income of the group, and (3) parameters describing the distribution of income within that sub-group. Results are reported for a given year by indicating the number and percentage of each subgroup which falls within certain income brackets (e.g., $0-4,000; $4,000-5,000; $7,500-10,000; $10,000-24,000; $24,000 and over). Twenty-five years is the longest future time horizon which the model has used to date.

Data Source

The estimated regression equations of the Age-Income Model of the Elderly are based on data from the Current Population Survey Annual Demographic File and various other sources. Future values for most variables are generated by the DRI Macroeconomic and DECO models, with minor adjustments to the population forecasts provided by the Census Bureau.

Model Specification

The forecast generated by the Age-Income Model can be thought of as taking place in two stages. In the first stage, equations are estimated using historical data to model the income distribution for each sub-group. In the second stage, the forecast is generated by applying predictions of future values of other variables to the estimated equations. The DRI Macroeconomic and DECO Models are simulated over the desired time

period, and results from these models are fed into the Age Income Model of the Elderly to generate the final income distributions.

The Model is based on the assumption that the income distributions for each sub-group follow a consistent pattern over time, and that such distributions can be determined from the parameters estimated in the model.

The distribution for each sub-group is determined by estimating five data points: (1) the real mean income of the group, (2) the ratio of the income level of individuals at the 10th income percentile to the median income level, (3) the ratio of the 90th percentile income level to the median, (4) the ratio of the 95th percentile income level to the median, and finally (5) the total number of individuals or families in the subgroup. The rest of the distribution is estimated based on the distributional assumption of a displaced log-normal curve with a Pareto tail that has the above five data estimates as parameters.

In the most recent version of the model (September 1984) 60 equations (five estimates by 12 subgroups) are estimated using 17 data units, the years 1967-83. Ordinary least squares multiple regression was the primary estimation technique, although four of the equations were estimated with corrections for first order serial correlation and three were estimated using ridge regression to correct for other statistical problems.

There is considerable consistency in the use of predictors within each variable type, although very few equations contain an identical set of predictors. Dummy year variables are used in some equations to account for "outliners" which could be the result of structural change, changes in data collection, statistical aberration due to small sample properties, or misspecification. As many as four dummy variables were used in one of the equations. The estimated equations are altered by adjustment factors.

Policy Experiments

Policy experiments are conducted by altering the models which provide input to the AARP model. For example, to examine the distributional effects of hypothetical changes in social security cost of living adjustments, the DRI Macroeconomic Model is adjusted to incorporate this change in the consumer price index and related price measures (limitations of this procedure are discussed in the analytic summary). The macroeconomic model, a 1002 equation simultaneous model, is then simulated with these adjustments, and then this output is run through the

Family DECO Model to address employment and retirement changes affecting the elderly and the average Social Security benefit paid per recipient. These results are then input into the AARP Model. The final results are compared with the results of a baseline simulation to determine the effect of the COLA change.

Model Review

Documentation

The structure of the Age-Income Model and the estimated equations are listed in detail in the 1984 DRI publication, The AARP Age-Income Model: Technical Appendix. The estimated equations are well-documented. For each of these equations the estimated parameters and accompanying statistical properties are listed. A description of the most recent forecast and analysis was published in The Outlook for Incomes of the Elderly through 1995. Detail on the assumptions, adjustment factors, and output from the DRI macroeconomic model are published monthly by DRI in a several-hundred-page document, Review of the U.S. Economy. The adjustment factors, history, and forecasts are also available on-line through DRI's databases. Assumptions and output from the DECO Models are published quarterly in the Demographic-Economic Forecast Summary. All of these documents are released by the U.S. Economic Service of DRI. Although the DRI Macroeconomic Model and the DECO Family Model must be solved prior to simulating the AARP Age-Income Model, no formal documentation currently describes this linkage.

Information on the analysis of the Social Security COLA changes was produced by DRI's Washington, D.C. Office and is described in 1985 publications Simulating the Effect of the CPI Minus 3% on Elderly Incomes and Simulating the Effect of a Freeze in Social Security Benefits on Elderly Incomes.

Maintenance

The model is maintained and updated on a regular basis. It has been updated five times since its creation, most recently in October 1984.

Validity

There is no published information on the operational validity of the model's forecasts, however, a comparison of results from the previous year's forecast to the current forecast can provide an indication of the model's accuracy to those evaluating it's implications. Developers report

doing some tracking of efficiency for internal use as well as solving the model over history to test its accuracy and help to create necessary adjustment factors for the forecast. Some validity information is published for the estimated equations which model historical data (the explained variance or R-bar-squared values range from .35 to .99). Although the developers report that they conduct sensitivity analyses, this is done during the estimation process and only the final results are reported.

The developers report that they monitor the shape of income distributions to test for changes. Based on a recent analysis they have concluded that the basic shape of these distributions has been consistent over time and can be described by a bell-shaped curve that tapers off at the highest income levels. Significant changes in the shape of income distributions could invalidate the model's assumption of a displaced lognormal curve with a Pareto tail.

Use

The model was commissioned by and continues to be used by the American Association of Retired Persons. The model is limited in its output in that it only provides estimates of total individual or family income, and does not provide estimates of the components of that income except at a very aggregate level. Interpretations of the model forecasts should be done with care recognizing the limited information on operational validity. Since the DRI macroeconomic and DECO models are an integral part of the AARP model's forecasts, recognition of those model's assumptions and adjustments is necessary in order to properly interpret the AARP forecasts. The relative computational simplicity of the model gives it an advantage in that it can produce forecasts relatively quickly and with less cost than the other models of retirement income.

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